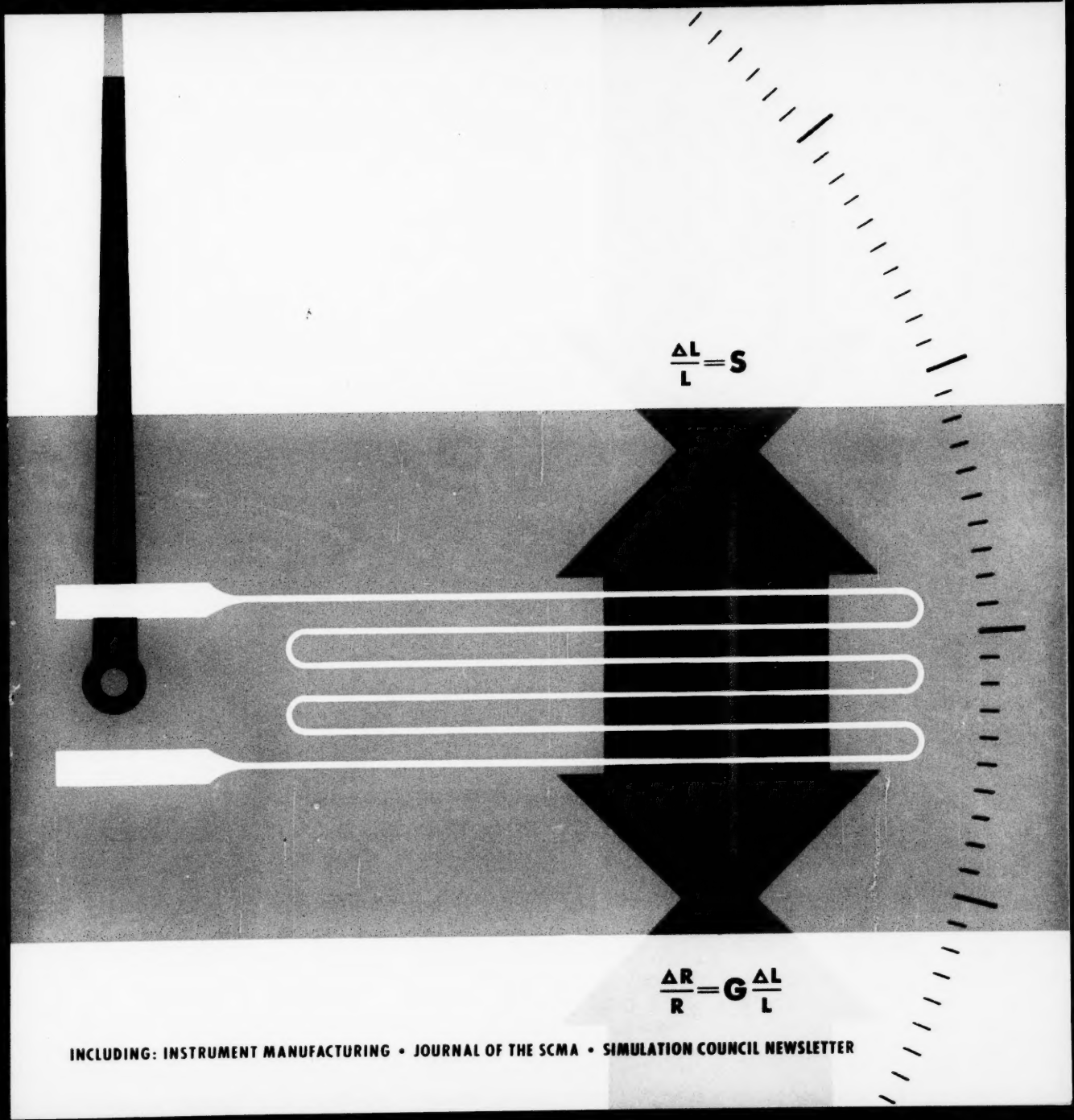
strain gage issue

MARCH 1958
OUR 31ST YEAR

INSTRUMENTS AND AUTOMATION



INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER

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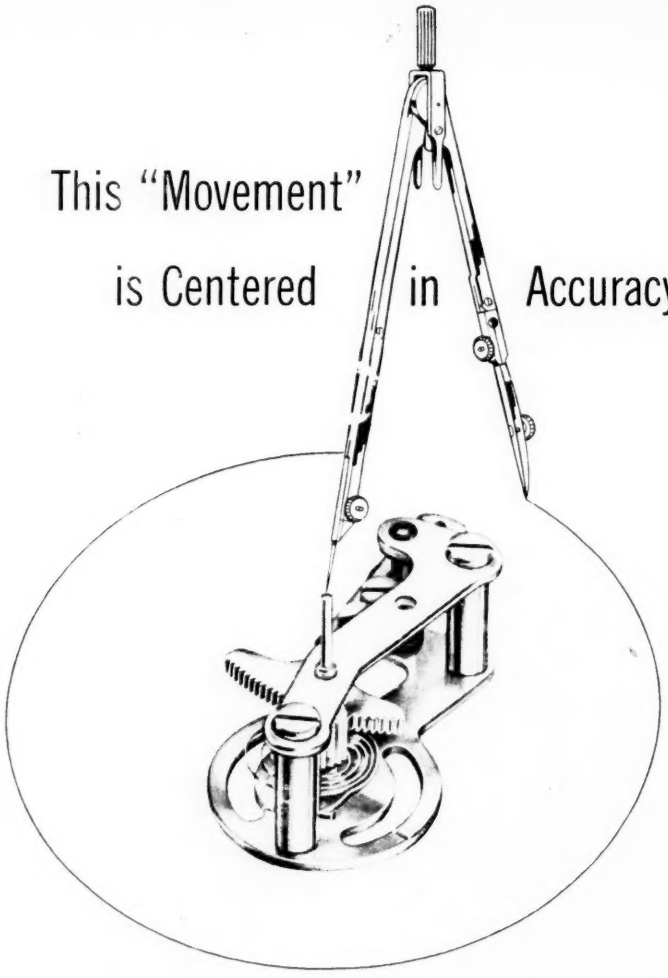

The rotary movement in Ashcroft Duragauges has a geared center shaft on which the pointer is mounted. When pressure flexes the Bourdon tube, the pointer is always positively positioned. You can rely on the Duragauge for precise accuracy in measuring pressure no matter how severe the conditions of service.

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For more information circle **1** on inquiry card.

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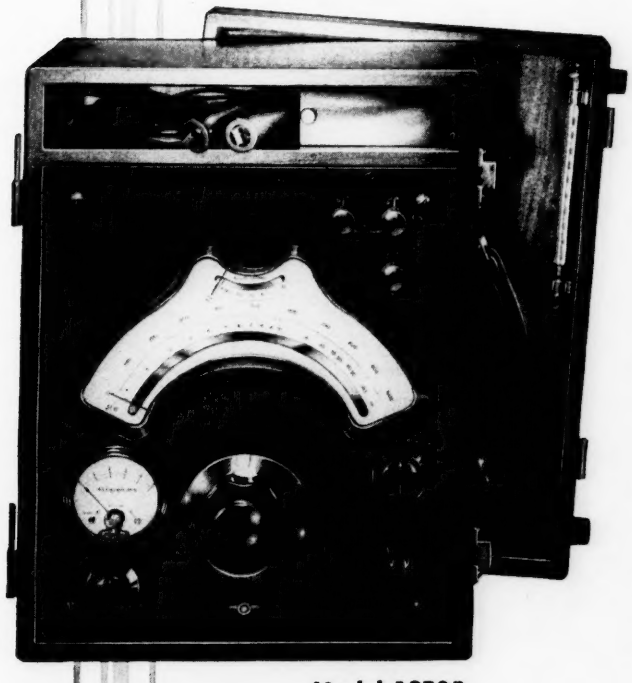

Model 13P05

For dependable maintenance, use test equipment made by the manufacturer of the components to be checked.

A PYROMETER-POTENTIOMETER

for measuring exhaust thermocouple temperatures that is truly portable with a sturdy pivoted galvanometer and without a standard cell. Accurate automatic electrically operated cold junction compensation permits this instrument to be used in ambient temperatures from below freezing to plus 120°F. Mirror scales with precise hand-drawn graduations and knife edge pointers insure accurate readings from zero to 1000 degrees Centigrade.

A LOW RANGE OHM-METER

with a widely spaced, hand drawn scale for checking the resistance of leads, thermocouples and balancing resistors to insure correct adjustment to match external resistance requirements of exhaust temperature indicators, either eight or twenty-two ohms.

A KILO-OHM METER,

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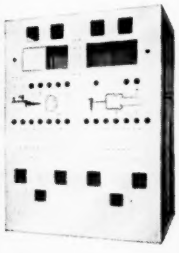

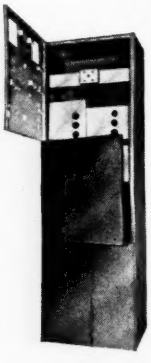

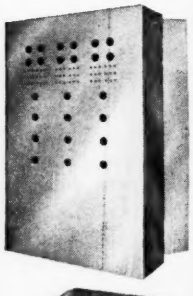

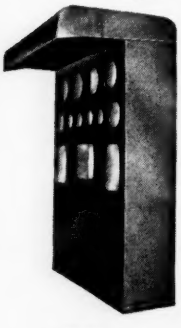

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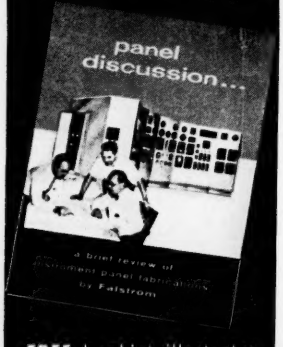

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MARCH 1958

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Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection

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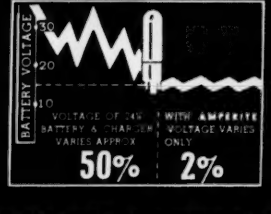

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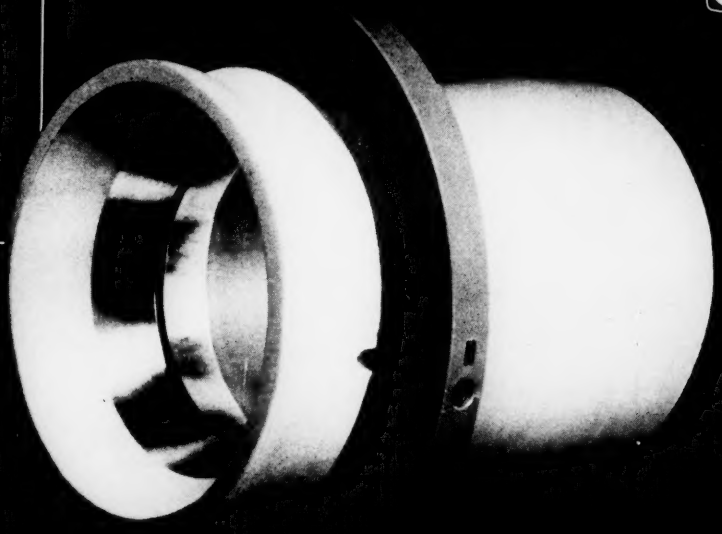

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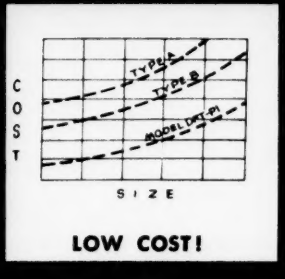

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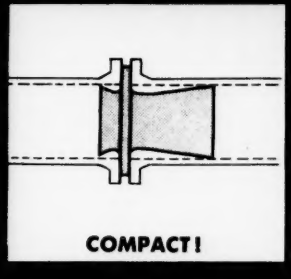

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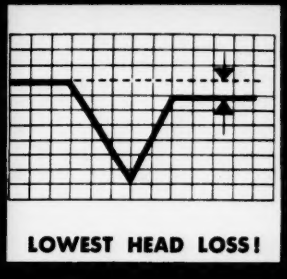

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Magnet Charger
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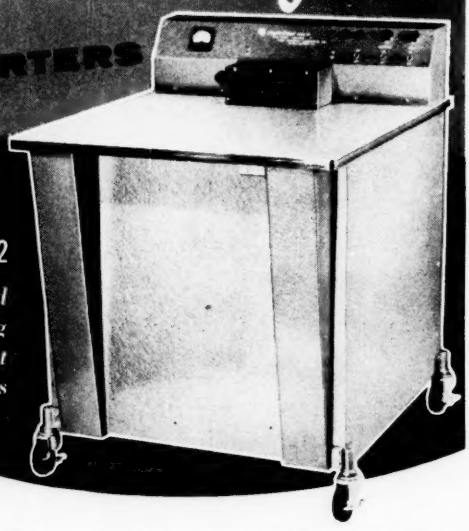
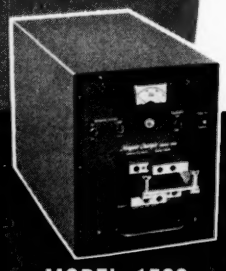


MODEL 942
Recommended by Leading Magnet Makers

3 VERSATILE MODELS

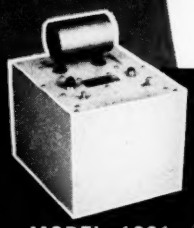
For saturating Alnico magnets weighing up to 34 lbs. and high flux ceramic magnets of any shape or pole configuration. Operates on condenser discharge principle from regular 115-volt, 60-cycle line.

Charging outputs from 100,000 to 200,000 ampere-turns through plug-in transformers, up to 3600 watt-seconds using wire-wound fixtures. Adapters for multi-pole rotors, rod, bar, ring and various other shapes available. Designed for continuous production use with low power consumption. Price of basic unit is less than $2100.



MODEL 1500

A medium power Magnet Charger capable of developing peak magnetizing force of 40,000 ampere-turns. Designed for production, research and instrument repair work. The Model 1500 easily saturates the new high coercive materials such as Cobalt Platinum and Barium Ferrite. Portable table model operates on 115-volt, 60-cycle line; size 11" wide x 15" high x 20" deep; weight 125 lbs. Price $945.



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to the editor

Editor, I&A:

The January issue of *Instruments and Automation* has had a great deal of attention here and our feeling is that the entire issue was very stimulating and your editorial, in particular, was a real contribution to some of the basic thinking that needs to be done.

Robert T. Rinear
Vice President
General Precision Equipment Corp.
New York, N. Y.

Editor, I&A:

It is my opinion that the editorial on Systems or Hardware was one of the best explanations that has been written on the subject. I think that the two concepts you outlined, one being basic and the other applied systems engineering, will clarify this subject in many peoples' minds.

The Systems Engineering Council would be in my opinion a very useful organization. I asked several of the people in our company what their reaction was to your January issue and they are all in full agreement with what I have stated above.

Thomas R. Hudson
Daystrom Systems
La Jolla, Calif.

Editor, I&A:

I enjoyed your editorial "Systems or Hardware?"—Jan. *I&A*. I heartily agree with you that the systems bandwagon is rolling too far. I think it is being distorted to furnish a sales tool. It is rather interesting to think that while we agree in the end effect, I would draw exactly the opposite conclusions relative to the complexity of the process problem of aircraft versus the process industries.

This doesn't deny your main point that "it is causing everybody to compete for everything . . ." You will find an almost identical discussion in my book under the chapter on procurement.

Your SEC idea is stimulating, however, and should provoke a lot of discussion. My principle concern would be whether you could really keep the thing on a highly ethical level or whether it would become a tool by which certain people protect their interests in the field.

James Bright
Harvard University
Graduate School of Bus. Adm.
Boston, Mass.

Editor, I&A:

The course in automation, electronics and instrumentation now under way in Pittsburgh is a step in the right direction and could be applied successfully in other sections of the country.

We are particularly interested in this program here at Mechanics Institute on a post-high school level as we are currently offering to industry-employed men an evening course beginning with the fundamental concepts of Basic Electricity and progressing through D.C. and A.C. theory to the practical applications of electrical theory to industrial needs today. In this program it is contemplated to emphasize the much needed applications of automation, electronics and instrumentation in the third year of the program. This phase will not be entered until September 1959 and therefore in the meantime we would appreciate any additional information as it becomes available on your experience with the Pittsburgh program.

Louis H. Rouillion, Director
General Society of Mechanics and Tradesmen, New York, N. Y.

Editor, I&A:

I would like to compliment you on your magazine which has been a "must" reading for me for several years. I have particularly enjoyed some of your editorials.

I also have your book "100 *Electronic Circuits*" and agree with the merits of your policy of publishing complete circuit details. It is a common complaint among engineers that they "copied" a circuit from a magazine, but were never able to make it operate properly—so decided to start from scratch.

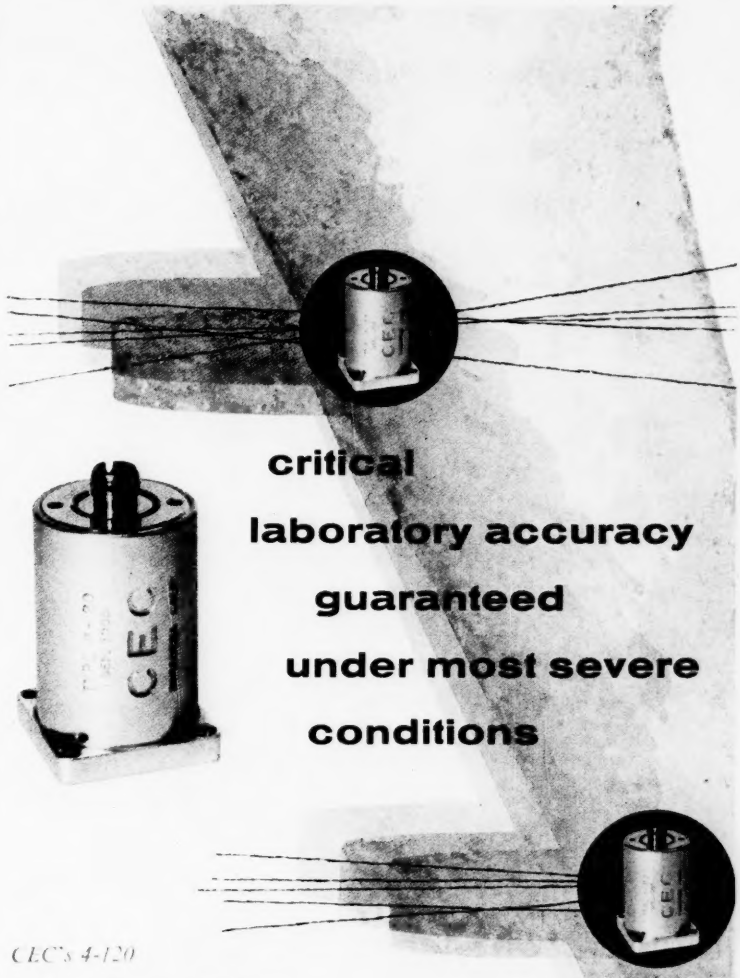
Hope you will consider another edition with both germanium and silicon transistor circuits. Also, a volume of circuits using "shelf-item" magnetic components.

Kenneth R. Jackson
Waugh Engineering Co.
Van Nuys, Calif.

Editor, I&A:

I congratulate you on the progress being made in the nation's first authorized public-high school course in automation, electronics and instrumentation.

The adaptation to other localities and other school systems will require selling. If done on a voluntary basis with approval from the public and boards of education, your objectives can be accomplished. Again, this will



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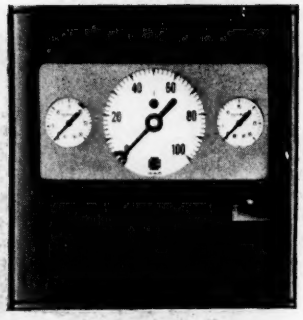
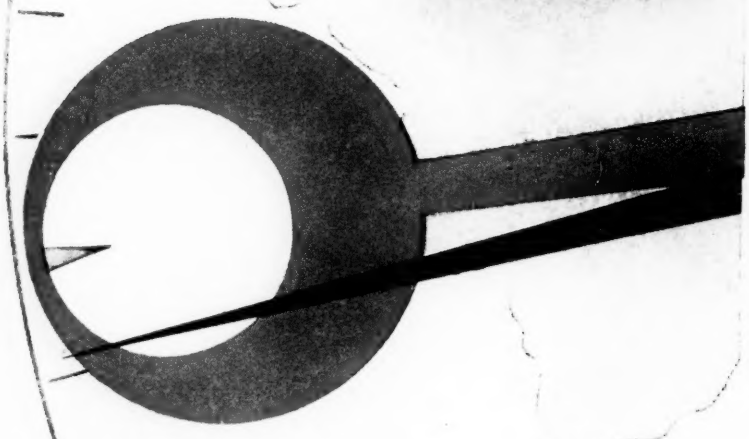




indicates set point and process variable at a glance!

plus . . .

- Standard proportional band 1-100% . . . also available to 150%.
- Proportional and differential gap actions easily selected with a screwdriver.
- Manual reset readily accessible. Automatic reset optional.
- Compact—8⅝" square x 4" deep.
- Pneumatic feedback circuit with sensitivity of 1/10% and repeatability of ½%.
- Available in a variety of temperature ranges; pressure ranges from 0-30" H_2O to 0-10,000 psi, and in vacuum ranges of 0-30" Hg.

No other pilot comes even close in a comparison of features with the USG Temperature or Pressure Pilot. The scope of applications is well beyond the range of ordinary pilots for flexibility and accuracy, and compares favorably with much more expensive controllers.

Write for descriptive catalog, or get it from your distributor . . . his name is in the "Yellow Pages" of your phone book.

UNITED STATES GAUGE

Division of American Machine and Metals, Inc.
Sellersville, Pa.

USG
Home of the SUPERGAUGE ®

MORE THAN 50,000 TYPES OF GAUGES • SUPERGAUGES • SOLID FRONT GAUGES • RECEIVER GAUGES • TEST GAUGES • RECORDERS • CONTROLLERS • TRANSMITTERS • PSYCHROMETERS • AVIATION INSTRUMENTS

For more information circle 9 on inquiry card.

require an organized campaign of selling.

Our educational systems are governed by no one controlling authority. Decisions affecting science education are widely decentralized in America. Only a full understanding of the science education problems on the part of parents, business and labor leaders, school board members, teachers, guidance counselors, public officials, newspaper publishers, civic leaders and many others will enable our students to seize the opportunities in sufficient numbers in science and engineering careers.

W. A. Schratz
Westinghouse Electric Corp.
Pittsburgh, Pa.

The most important aspect of the Pittsburgh experiment is its technique for obtaining the cooperation of local technical societies, who advise the teacher, plan experiments, and actually conduct phases of the curriculum.

Editor, I&A:

Your editorial on the current technical education situation is very well stated. Could you please send me 20 copies of this editorial? I would like to forward it to all FIER trustees.

Incidentally, the Foundation now has a committee solely concerned with its planning and action in the area of post-high school and vocational education. Judd Vollbrecht of Energy Control Co. is Chairman; others on it are Gordon Brown, Rowland Burnstan, Hugh Colvin, and Jack Frost.

Regarding the concept of your course, I personally feel it is excellent and could very well stand duplication in many cities equal in size or larger than Pittsburgh. However, I also feel that effort must be expended to place an applied phase of this subject into the curricula of vocational high schools; that the Pittsburgh course as such has much more meaning from the standpoint of *reinforcing* the higher level student's decisions to go into science and/or engineering, but that a parallel effort must be made to salvage technically adroit but non-college young people for work in this field.

Lloyd Slater
Foundation for Instrumentation Education and Research
New York, N. Y.

Where is such effort not needed? At least we started somewhere!

Editor, I&A:

We should like to ask permission to duplicate Page 677 of your April 1957 issue for school use, entitled

"A Yardstick for Automation" by Amber and Amber. Each of our high schools have been subscribers to *Instruments and Automation* for several years and we have found it very helpful. The information about automation that you have prepared would be valuable to give a bird's-eye view of this subject and we hope you will permit us to use it for distribution to our sixty-five science teachers.

M. Marcus Kiley
Assistant Superintendent
Public Schools of
Springfield, Mass.

We are delighted to help!

Reader Inquiries

Electronic Lock

Importer in Sweden would like to identify manufacturer of "electronic lock" with key of cardboard combined with parts of metal and plastic. Electronic scanner in lock identifies combination. A-300

Pneumatic Room Thermostat

Control service company is seeking pneumatic room type thermostats. A-298

Small Electroplating Outfit

Owner of electrical manufacturing company seeks a small electro-plating outfit for brass nuts and screws up to 8" long. Electrolyte should be of such composition that it will not spoil from lengthy idleness. A-299

Electronic Circuits Wiring Manual

Engineer in missiles division of electronic manufacturing company wishes to acquire text or manual dealing with practical aspects of wiring and cabling of electronic circuits. A-301

Automatic Profile Cutter

Engineer would like to find supplier of machine to cut wood parts automatically by following outline on drawing or edge contour. A-302

Organic Gaseous Compounds in Air

Chemist is seeking device to record qualitative and/or quantitative presence of organic compounds of the "odores ambrosiaci group" (typified by amber and musk) in air samples. A-303

Compression and Explosion Pressures

Plant foreman in petroleum industry is interested in obtaining equipment for accurately testing gas engine power cylinder compression and explosion pressure. A-304

RAMBLINGS ON INSTRUMENTATION

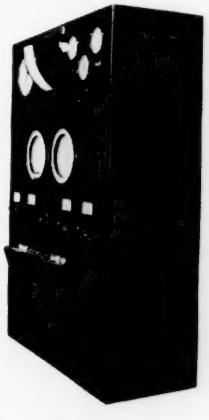
One good package deserves another

The trend to pre-assembled or "packaged" products has spanned everything from cake mixes and frozen TV dinners to naturally enough, boilers.

In step with the supermarket trend in the power field, Hays manufactures "instant" controls, completely pre-assembled and packaged and ready for use with your new package or field-assembled boiler. A wrench and a handy a-c outlet are just about all you need.

The packaged controls we make are designed specifically to deliver the economy you hoped for when you invested in a new boiler. We manufacture these electric automatic controls in ten different systems, each of which is sympatico with a particular boiler type.

Hays electric control packages are complete. Controllers, instruments, switches, valves, strainers, regulators, egg yolks . . . everything is in position. Installation is simple, but if you're all thumbs, a service man of your local Hays representative is available to help with installation and start-up.



• *Packaged Control Panel*

Hays control systems possess more virtues than you could reasonably expect from their flesh-and-blood counterparts in the human race: sobriety, patience, alertness, stamina and all that. Yet they demand nothing from Man save an occasional swipe with a dustcloth and an affectionate pat.

Undistracted by the superintendent's blond secretary or World Series pools, they concentrate on what's going on inside the boiler. They automatically modulate the boiler from maximum to minimum load at peak efficiency, and even to low load on-off operation. As required, they will take a boiler in or out of operation safely and automatically.

Switches and indicating lights are grouped neatly on a handsome console set at keyboard height (see keyboard and well-manicured hand below) with enough room left over for a brace of candelabra—if you like atmosphere in the boiler room.

• *Console Close-up*

Your consulting engineer will usually recommend that you place the responsibility for providing controls with a control manufacturer, rather than the boiler manufacturer. This makes sense. It affixes the responsibility for safe, efficient control where it ought to be and relieves everyone concerned of a potential king-size headache.

Whaddaya know? Premiums!

In a moment of sheer madness, we bought some miniatures of our packaged controls designed for use as banks. Idea was that this gets across the association of Hays controls with economy. Well, anyway, we have them. You might like one for your kids or yourself. Ask for a couple and make our ad manager happy. He sometimes gets pensive wondering "does anyone *read* all that copy?"

For a prose treatise on our complete line of Electric Packaged Control Systems, drop me a hint that you'd like our bulletin 57-1088-239, just off the press.

Phil Sprague Jr.
President

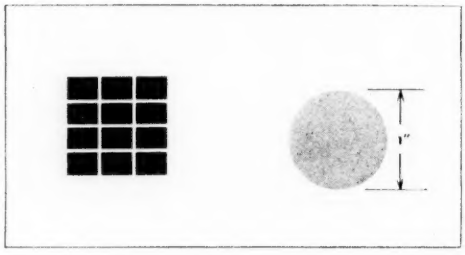
THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

For more information circle **10** on inquiry card.

HOW ONE CONCEPT IN POTENTIOMETER DESIGN SOLVES THREE BASIC PROBLEMS

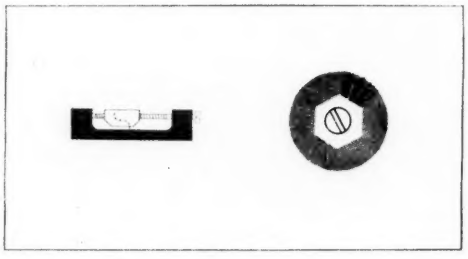
SPACE-SAVING SIZE AND SHAPE

You can pack a lot of Bourns potentiometers into a small space—12 in one square inch of panel area (or 17 TRIMPOT JR.* units!) Fit them into corners, between other components, flat against chassis or printed circuit boards. Mount them individually or in stacked assemblies.



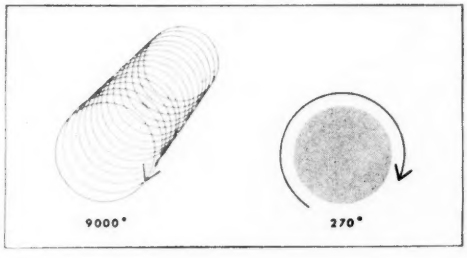
ADJUSTMENT STABILITY

Bourns potentiometers are *self-locking* (no lock nuts required). Any adjustment *remains* stable. Shock, vibration or acceleration can't affect a setting. Bourns potentiometers are helping thousands of engineers make reliability a reality.



CIRCUIT BALANCING ACCURACY

Bourns potentiometers are 33 times as accurate as conventional single-turn rotary types—the screw-actuated mechanism provides 9000° of rotation instead of only 270°. Circuit balancing, calibration—adjustments of all types are easier, faster, more precise. And repeatability is assured.



BOURNS

Laboratories, Inc.

P. O. Box 2112 • Riverside, California

ORIGINATORS OF TRIMPOT® TRIMIT® AND POTENTIOMETER INSTRUMENTS

*Trademark

HERE ARE ADJUSTMENT POTENTIOMETERS TO MEET ALL YOUR REQUIREMENTS

high performance military potentiometers and rheostats

General Purpose Type

The original wirewound TRIMPOT®. Model 200 (terminals L, S or P – see drawings below). 105° C operation. 0.25 watt. Also available as a rheostat, Model 201 TrimR® (terminal L only).

High-Resistance Wirewound

Hi-R® TRIMPOT Model 207 (L). Resistances to 250 K. 175° C operation. Two watts. Rheostat: Hi-R TrimR Model 208. (L)

Micro-Miniature Potentiometer

The TRIMPOT JR.* Model 222 is so small you can fit 17 units in one square inch of panel space. 175° C operation. One watt. Humidity proof. (Terminals L or W).

High-Resistance Deposited Carbon

An unusually significant achievement in military quality potentiometers – infinite resolution at 125° C operation. 0.25 watt. Uses the RESISTON* element, a product of 3 years of Bourns research. 20K to 1 megohm range. TRIMPOT Model 215. (L, S or P).

Dual Potentiometer

TWINPOT® Model 209 is two potentiometers in one. (L). 105° C operation. 0.25 watt.

High-Temperature Operation

175° C operation. One watt. TRIMPOT Model 260. (L, S or P). Available as a rheostat Model 261 (L).

Humidity Proof, 135°C Operation

TRIMPOT Model 236. (L, S or P). 0.8 watt. Also available as a rheostat, Model 231. (L).

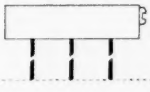
low-cost commercial adjustment potentiometer

TRIMIT® – an important new development for manufacturers of computers, industrial controls, communications equipment and high-quality test and measuring equipment. Provides 33 times the adjustment accuracy of single-turn rotaries, occupies only a fraction of the space, and has far greater stability of setting – *at no additional cost.* Wirewound Models 271 (L), 273 (S), 275 (P). Carbon Models 272 (L), 274 (S), 276 (P).

military and commercial units available in these terminal types:

L = Leads, insulated, stranded

P = Pins, printed circuit



S = Solder lugs

W = Wires, uninsulated

Visit our booth #3716-3718 at the I. R. E. Show

Write for detailed technical information on Bourns Potentiometers. Please specify the model or type and mention your application.

BOURNS

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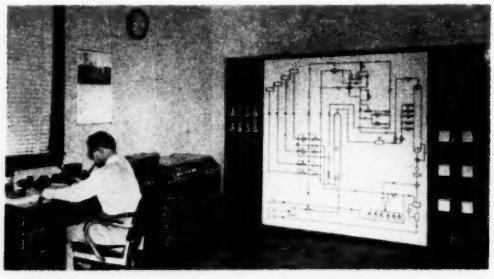
ORIGINATORS OF TRIMPOT® TRIMIT® AND POTENTIOMETER INSTRUMENTS

news

Computer-Controlled Pilot Plant Speeds Research on Processes

LINDEN, N. J.—A computer-controlled pilot plant is being built by Consolidated Electrodynamics' System Division that will enable Esso Research & Engineering Co. to determine optimal process methods before the plant for a product goes up. The automatic miniature plant will speed up research with eventual savings of millions of dollars.



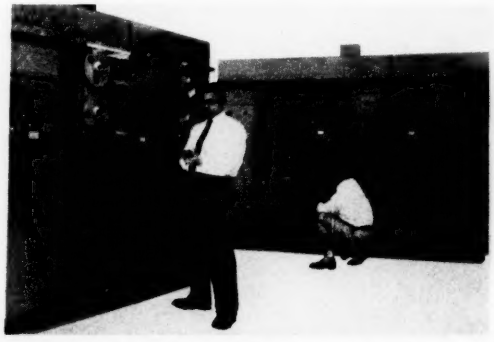
After the introduction of a previously prepared catalyst cartridge into the reactor section, an automatic program system centered about an LGP-30 desk-size computer (built by Librascope) will take over and conduct round-the-clock tests, constantly analyzing raw materials and products. A complete record of temperature, pressure, flow rate, chemical composition and other variables at any time is then printed out continuously, and information is fed into the computer automatically several times a second. The computer digests the data and presents them to the engineer in charge in a form whereby he can easily evaluate them. The goal is to find ways of turning petroleum into additional valuable products such as new types of petrochemicals, fuels, and lubricants. Picture shows artist's conception of control room.

BIMCAM News

LONDON, ENGLAND—BIMCAM, the British Industrial Measuring and Control Apparatus Manufacturers' Association, held its Annual Luncheon in London, January 7th. Mr. S. P. Chambers, Senior Deputy Chairman of Imperial Chemical Industries Ltd. (shown with glass in center of picture), foresaw greater use of industrial instruments; Mr. E. W. Wilson, Chairman of BIMCAM, shown at right, announced that the Instruments, Electronics and Automation Exhibition in April would be international for the first time; Mr. L. S. Yoxall, President of BIMCAM, (left center) pointed out the shortage of technical manpower at all levels as being the greatest limitation on industrial progress. Also shown in picture is Mr. J. B. L. Munro, of the Engineering Division, Board of Trade (left).

GE System Speeds Missile Data Processing

PHILADELPHIA, PA.—A major advance in automatic data reduction has been realized with the successful installation of a new high speed Telemetry Data Reduction System at the General Electric Missile and Ordnance Systems Department in Philadelphia. After a missile has been fired data must be ready for evaluation by the engineers within three days in order to be helpful on the next shot. This can be done now with a new system, designed and built by Epsco, Incorporated, which automatically prepares telemetry data for analysis in a large scale digital computer. Inputs to the system are magnetic tape recordings of data telemetered to the ground during missile flights. Four completely separate reduction facilities are included in the system—two for FM/PAM data and one each for FM/PDM and FM/FM data. Each facility demodulates and digitizes the input data, then automatically records the digital information on magnetic tape in proper format for entry into a digital computer.



THE FM/FM AND FM/PDM CONVERSION FACILITIES and associated output Digital Recorders shown comprise approximately one-third of the system. Not shown are 20 racks containing FM/PAM conversion facilities, additional Digital Recorders, 12 Analog Tape Transports, AFMTC Time Code Translators, and System Test Equipment.

Over-all dynamic system error from input analog tape to output digital tape is less than 0.5%. Data reliability is even further enhanced by elaborate self-check provisions.

new

Frequency Changer for WIDE RANGE of FREQUENCIES...EXCELLENT REGULATION ...LOW DISTORTION

See the NEW Nobatrons— and **all** *the new Sorensen Power Supply developments —both AC and DC at our IRE exhibit.*
Booths 2627-2629

This NEW FCR100—latest addition to the Sorensen line of Frequency Changers—supplies a frequency range from 45 to 2000 cycles with exceedingly good wave form, and matches the other Sorensen Frequency Changers in uniformly excellent performance.
The low output harmonic distortion, with consistently reliable regulation of frequency *and* voltage, makes each of these Frequency Changers ideal for critical applications.
Let your Sorensen representative supply you with full details on these Frequency Changers—with or without filters.
Or write directly to headquarters for technical data.

FCR250

FCR100
Input Freq.: 45-65 cps
Output Freq.: 45-2000 cps
Out. Freq. Regulation: ±1% or ±0.01% with suitable external standard
Load Range: 0 to 100 VA.
Input Voltage: 105 to 125 VAC
Output Voltage: 115 nominal VAC
Harmonic Distortion: 1% maximum
$530.— in cabinet.

FCR250
Input Freq.: 45-65 cps
Output Freq.: 320-1000 cps
Freq. Reg.: ±1.0%; or ±0.01% with optional internal frequency standard
Load Range: 0 to 250 VA (500 VA at 400 and 800 cps)
Voltage Input & Output: 105 to 125 VAC
Voltage Reg.: ±1%
Harmonic Distortion: 5% typically
$990.— in cabinet.

Note: This distortion value can be reduced to 3% from 350 to 450 cps, and to 2% for specific tuned frequency, by inserting the NEW FCF 250 Filter in the output line.

Sorensen

CONTROLLED POWER FOR RESEARCH AND INDUSTRY

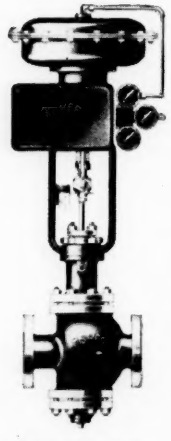
SORENSEN & COMPANY, INC.
Richards Avenue, South Norwalk, Connecticut

In Europe, contact Sorensen-Ardag, Eichstrasse 29, Zurich, Switzerland, for all products including 50 cycle, 220 volt equipment

For more information circle **12** on inquiry card.

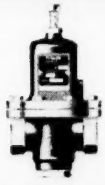
The FISHER

Stocked and Staffed to

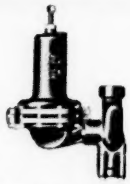


Type 657-A with 3500 Positioner

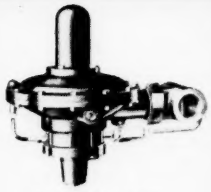
Type 4150 and 4160 Wizard II Pressure Controllers



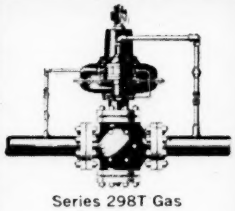
Type 95-H Pressure Reducing Valve



Type 630 "Big Joe" Field Regulator



Series 99-I Multi-Purpose Gas Regulators



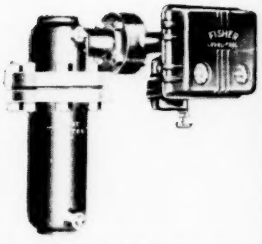
Series 298T Gas Regulators

Type 655-A Pressure Regulator

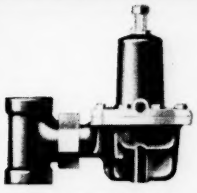
IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

"Supermarket"

give 36 hour Factory service!



Series 2500-249 and
2500-259B
Level-trols
Cage Sizes 14" and 32"



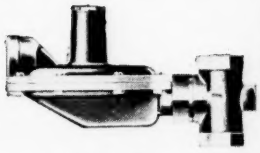
Series 620 and 621
Farm Tap Regulators

Series 67FR Combination Filter Regulator

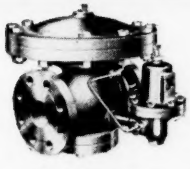
Yes, now you can shop by phone, wire or TWX (Marshalltown 578 or 579) and expect shipment of the equipment illustrated at left in a matter of hours. Now that Fisher Control Valves and Regulators are as readily available as your supermarket groceries, you can meet your emergency needs quickly. Fisher carries a stock of the popular and standard size control valves, displacement type liquid level controllers, pressure regulators and gas regulators on the "supermarket" shelf at all times. The offices in red maintain a wide selection of Fisher equipment in their own inventory.

New items will be added from time to time as needed. Each Fisher representative receives a weekly list of all available types and sizes.

Now, for emergency needs contact either the Fisher representative or the Fisher home office. Your order will be en route within 36 hours (except Saturday and Sunday) after it is received in Marshalltown.



Series S100 and 730
Service Regulators



Type 92B Pilot
Operated Steam
Reducing Valve

AMARILLO
Vinson Supply Company
ATLANTA
J. M. Smither & Company
BALTIMORE
The Rhodes Controls Company
BIRMINGHAM
Joseph W. Eshelman & Company
BOSTON
Clarence B. Petty & Company
BUFFALO
W. J. Sommers Company
CALGARY-EDMONTON
Barber Engineering & Supply Company
CARACAS, VENEZUELA
Sinclair Spence
CHARLOTTE
Robert E. Mason & Company
CHICAGO
General Meters & Controls Company
CINCINNATI
H. T. Porter Company
CLEVELAND
A. E. Ehrke & Company
DALLAS
Vinson Supply Company
DENVER
Joy & Cox, Inc.
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Puffer-Sweiven Company
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Mechanical Valve & Engineering Spec.

Offices listed in red maintain field stock.

FISHER®

SINCE 1880

FISHER GOVERNOR COMPANY

Marshalltown, Iowa/Woodstock, Ontario/London, England

For more information circle **13** on inquiry card.

GREATER SIMPLICITY

FOR LIQUID LEVEL

For more information circle **14** on inquiry card.

MEASUREMENT !

Easy Low-Cost Installation on any closed or open tank. Only two small pressure taps required. Nothing inside tank!

Fully-Adjustable Ranges . . . 0-20" to 0-250" and 0-200" to 0-800" H_2O.

Complete Adjustment for elimination of outside leg effect gives forward-reading signal to any standard receiver!

Highest Sustained Accuracy . . . Instant, precise response to level changes even under extreme operating conditions.

Rugged and Corrosion-Resistant . . . Level-sensing element is Type 316 stainless steel, silicone-filled "capsule" diaphragm applicable on static pressures up to 1500 lbs.

There's nothing simpler for accurately measuring liquid level than the Foxboro Type 13LA d/p Cell* Liquid Level Transmitter! No floats, knife edges, stuffing boxes, or complicated hook-ups. A simple, direct piping job connects it to the tank . . . operates in any position, even upside down. The Transmitter precisely measures difference in head caused by level change . . . sends 3-15 psi air signal over single air line to indicator, recorder, or controller. It's easily traced when required, up to 250°F., to maintain fluidity of liquid.

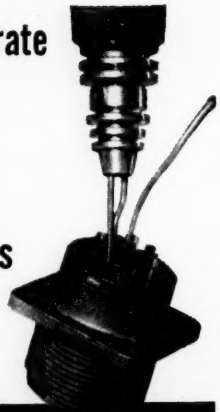
The 13LA d/p Cell Transmitter is low in initial cost, requires practically no maintenance. In addition, it is easily converted in field for the measurement of fluid flow. It's the ideal instrument for heavy industrial applications . . . indoors or out. For complete details, ask your nearest Foxboro Field Engineer, or write for new Bulletin 13-22A to **The Foxboro Company, 463 Norfolk St., Foxboro, Mass., U.S.A.**

*Reg. U. S. Pat. Off.

FOXBORO REG. U. S. PAT. OFF. **LIQUID LEVEL TRANSMITTER**

For more information circle **14** on inquiry card.

HOW pinpoint accurate RESISTANCE SOLDERING reduces voids--pullouts and COSTS!



IDEAL

Thermo-Tip

FOR MINIATURE and SUB-MINIATURE PRODUCTION SOLDERING

ENDS "COLD-FLOW" WASTE

In IDEAL Thermo-Tip *Resistance* Soldering, the work itself acts as a resistor, serves as the heating element. This positively prevents "cold-flow" joints — a chief cause of solder voids, pullouts, rejects or costly rework.

INCREASES OUTPUT

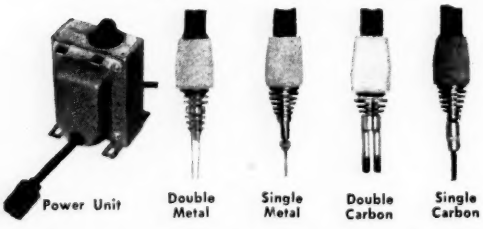
Overall time-cost savings of about 25% are reported on such typical jobs as soldering plug pins, when low-cost Thermo-Tip replaces older methods. Sound joints are often made in 1 second, using only *safe* low voltage, high amperage. Concentrated, accurately controlled heat eliminates burn damage to adiacent parts.

REDUCES OPERATOR FATIGUE

Pencil-light handle and electrode reduces operator fatigue and further helps boost output in continuous production.

ATTACHMENTS TO MEET YOUR EXACT NEEDS

There is an IDEAL Thermo-Tip Attachment and Power Unit for every precision soldering purpose, with easy adjustment for specific job needs.



Sold through America's Leading Distributors — OR MAIL COUPON
In Canada: Irving Smith, Ltd., Montreal

IDEAL INDUSTRIES, Inc.
1420-C Park Ave., Sycamore, Ill.

Gentlemen:
Kindly send us complete catalog information of Ideal's Thermo-Tip Resistance Soldering Tools.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

For more information circle **15** on inquiry card.

NEWS —CONTINUED

Magnetohydrodynamics

EVERETT, MASS.—Magnetohydrodynamics (MHD), the science of interaction of ionized gases and magnetic fields, is used in Avco's Research Lab. to generate electric power directly from nuclear or other thermal sources without use of mechanical energy as an intermediate step. MHD is viewed as seriously competing with chemical rockets and ion rockets for the conquest of space.

Chambers of Commerce Appeal to Instrument Industry

PITTSBURGH, PA.—Local areas are making attractive offers to the instrument industry, pointing out various advantages of these areas for location or relocation of instrument companies. These areas include the Florida State Chamber of Commerce (Jacksonville 11, Fla.), Puerto Rico Economic Development Administration (Tishman Bldg., 666 Fifth Ave., New York 19, N. Y.) and various Nevada communities (contact Western Nevada Industrial Development Commission, 125 Gazette Bldg., P. O. Box 774, Reno, Nevada).

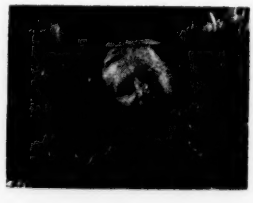
News Bits

THE WESTERN REGIONAL STRAIN GAGE COMMITTEE has been formed "devoted to the study of Strain Gage problems." It comprises some thirty divisions of 14 industrial units. The group acts as an independent unit, is not affiliated with any other society, and holds semi-annual round-table 1-day committee meetings. Honorary chairman is Dr. Wm. Murray, Professor of Mechanical Engineering, MIT; Chairman is Philip Vulliet, Douglas Aircraft Co., Long Beach, Calif.

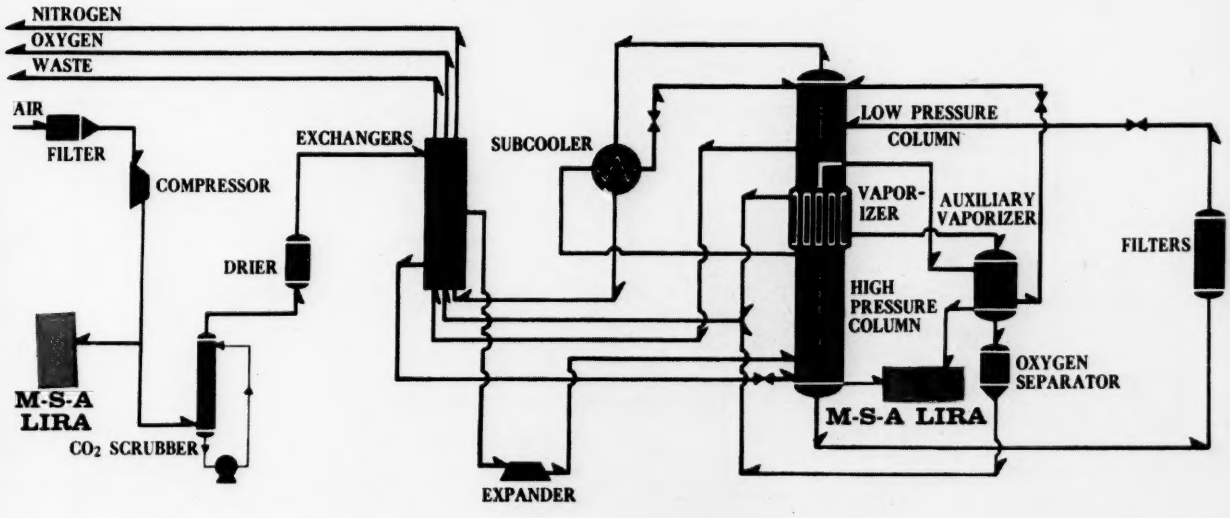
MASSACHUSETTS INSTITUTE OF TECHNOLOGY announces that its 2-week summer course in Strain Gage Techniques will be held July 8-12 and 14-18, including demonstrations and lectures by Dr. Wm. Murray of MIT, Peter Stein of Stein Engineering Services, and others. Same course will be given at University of California at Los Angeles, August 18-22, and 25-29.

STRAIN GAGE READINGS, a new periodical devoted exclusively to the electric resistance strain gage, will be issued bi-monthly starting in April-May, 1958, by Stein Engineering Services, 5602 Monte Rosa, Phoenix, Arizona. Cost: $10 per year.

SAMA, the Scientific Apparatus Makers Association, will hold its fortieth Annual Meeting in Palm Springs, Calif., April 20-24. Some 350 instrument company executives will hear prominent speakers discuss topics such as the business outlook and problems of instrument companies, reducing marketing costs, and what's new in industrial relations. SAMA president R. E. Welch will preside; Bernard Kearney, president, The Torsion Balance Co., is program committee chairman.



Among **GENERAL ELECTRIC's** most important 1957 research achievement is Dr. Volney C. Wilson's new thermionic converter which has converted directly more than eight percent of applied heat energy into electric power.



Flow diagram of a standard medium pressure air separation cycle employing M-S-A LIRA Analyzers for plant safety.

M-S-A® LIRA Analyzers can protect your oxygen plant

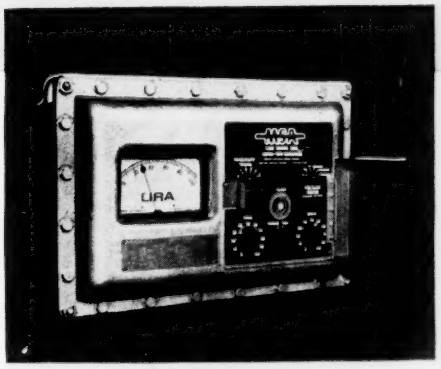
You can keep strict tabs on dangerous accumulations of acetylene and total hydrocarbons by continuously monitoring the air stream and the liquid pool with M-S-A LIRA Infra-Red Analyzers

Safe operation of air separation equipment demands continuous monitoring of acetylene. This troublesome hydrocarbon contaminant has very low solubility and is highly reactive. That's why a number of plants throughout the country are installing M-S-A LIRA Infra-Red Analyzers for explosion prevention.

These versatile instruments measure acetylene and total hydrocarbons in the air intake streams, as well as in the liquid pool itself. Model 100 LIRA Analyzers have been sensitized for full scale ranges of 1.0 and 2.0 ppm acetylene. Thus, it is possible to measure concentrations as low as 0.02 ppm acetylene. With this sensitivity it is also possible to continuously monitor the air stream and sound an alarm in the event a large concentration is suddenly drawn into the plant or, if there is a gradual build-up.

Model 200 Analyzers have been provided to measure the total hydrocarbons present in the air stream as well as the liquid oxygen pool. By means of these instruments, operators are advised at all times of the degree of contamination in the system, and can take steps to prevent development of explosive mixtures.

An M-S-A Instrument Specialist will be happy to discuss your product contamination problems. Write us for helpful literature.



Explosion-proof Model 200 has a tamper-proof lock, and all controls are easily accessible through the explosion-proof enclosure.

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

For more information circle **16** on inquiry card.

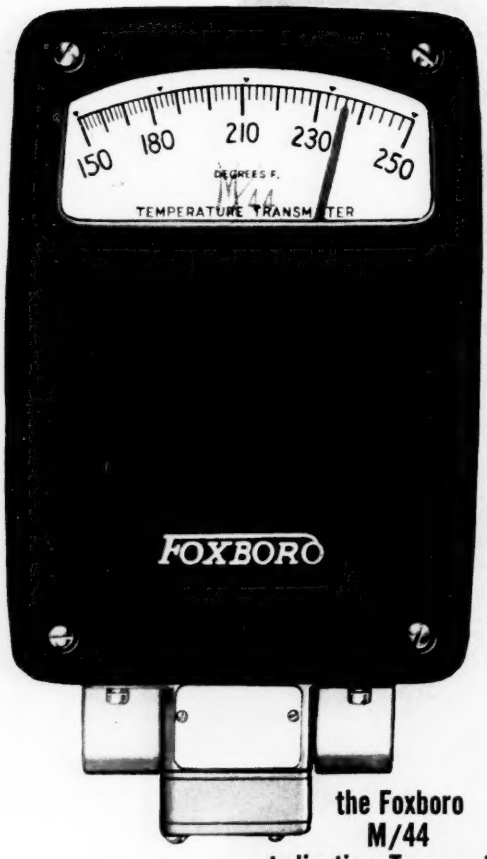
new from Foxboro!

a compact, low-cost

INDICATING TEMPERATURE TRANSMITTER

engineered for fast, sensitive response under roughest field conditions.

– uses any filled thermal system



the Foxboro M/44 Indicating Temperature Transmitter

Here's a brand new instrument engineered specifically for its job of indicating and transmitting temperature.

The M/44 Indicating Temperature Transmitter offers the inherent simplicity of a motion balance instrument. Compact and lightweight (10 lbs.) its indicating scale and fluorescent red pointer are visible up to 20 feet away. The output pressure of the M/44 is transmitted to any remote 3-15 psi recorder, controller, or indicator.

The M/44 is made with standard performance-proved Foxboro components, simply and conveniently arranged in a weather proof steel case. Changing range or type of thermal system can easily be done in your own plant.

Thanks to its rugged construction, the new M/44 is unaffected by vibration, sudden shock, or corrosive atmosphere. Even in the event of air supply failure, this instrument continues to indicate process temperature.

Ask your Foxboro Field Engineer about this new instrument. Or write for Bulletin 456-20A, **The Foxboro Company, 463 Neponset Ave., Foxboro, Mass.**

Choice of Thermal Systems

Foxboro M/44 Transmitters are available with any filled thermal system. These classes are suggested for particular range characteristics:

Class II Vapor Pressure (100° to 600° F)
Lowest cost, fastest response, highest sensitivity. Recommended for all installations within this range except when the measured temperature crosses ambient temperature.

Class IA & IB Liquid Expansion (−250° to +600° F)
Good response, good sensitivity, uniform scale. Uses smallest bulb of any filled thermal system.

Class III Gas Pressure (−450° to +1000° F)
Applicable to ranges beyond the limits of other filled systems. Uniform scale. Bulb has long sensitive section; permits useful averaging measurements.

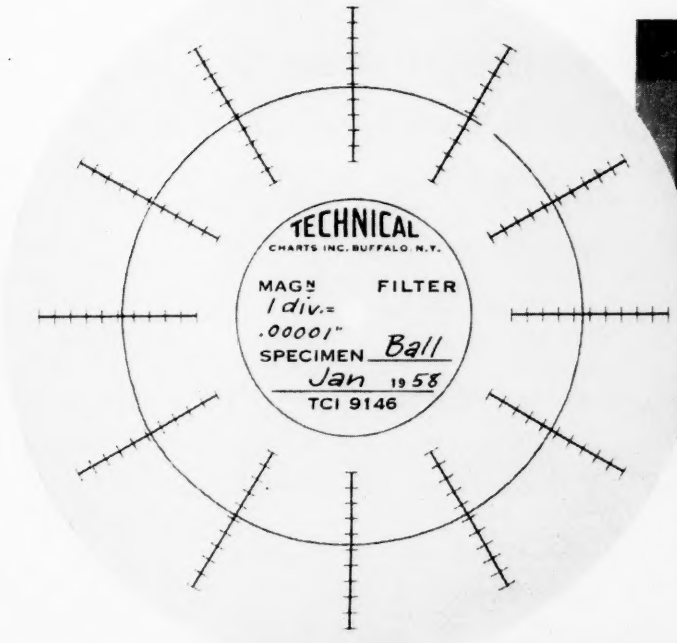
green area is actual size silhouette of the new M/44

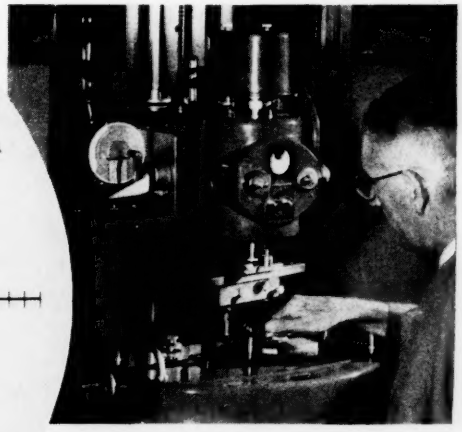
FOXBORO
REG. U.S. PAT. OFF

TEMPERATURE MEASUREMENT AND CONTROL

For more information circle **17** on inquiry card.

FACTS





Accuracy measured in millionths of an inch, made visible to the human eye. Steel balls, the heart of New Departure precision ball bearings, held to 5 millionths of an inch or less in sphericity. Graph at left shows sphericity variation of a ball on the order of one millionth of an inch (.000001") measured by Talyrond Machine. Graph radial divisions are .00001".

The extreme accuracy of New Departure ball bearing component parts is now playing a vital role in successful missiles for the Army, Navy and Air Force. Above —typical bearing parts, less separator —unretouched photograph.

PORTRAIT of PRECISION!

A mechanism is only as accurate and reliable as the bearings supporting its moving parts. For the designer the problem is how to achieve the essential rigidity or *accuracy* of *location*, yet be assured of extreme *freedom* of *rotation*.

A "tip-off" to the solution lies in the chart above—super-precise steel balls, the heart of New Departure precision ball bearings. For, with balls held to 5 millionths of an inch or less out-of-roundness and other bearing parts finished with comparable care, such bearings can be mounted and *preloaded* to provide the hairsplitting exactness of location and *ease of rotation* required of the finest precision instruments.

The AChiever guidance system proved in tests of the Air Force's Thor ballistic missile demands tolerances often measured in millionths of an inch, as is the case with the New Departure ball bearings on which the AChiever's precision gyros turn.

1908—1958
GM
FORWARD FROM FIFTY

NEW EPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

For more information circle **18** on inquiry card.

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Look for this world-famous trade-mark on scientific instruments

A few outstanding instruments embodying the traditions of this trade-mark:

LARGE TOOLMAKER'S MICROSCOPE
INTERFERENCE MICROSCOPE
LIGHT SECTION MICROSCOPE
OPTICAL DIVIDING HEAD
CIRCULAR DIVISION TESTER
ULTRAPHOT II for incident illumination
PHOTOMICROSCOPE for incident illumination with automatic exposure-setting device
METALLURGICAL MICROSCOPE
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For more information circle **19** on inquiry card.

GOW-MAC THERMAL CONDUCTIVITY
GAS ANALYZERS

—*for* GAS PURITY, GAS MIXING AND PROCESS CONTROL OF

Argon
Carbon Dioxide
Deuterium
Ethylene Oxide
Freon (Genetron)
Helium
Hydrogen
Ortho-Para Hydrogen
High Energy Fuels
Nitrogen
Oxygen
Special Atmospheres
— And Many Others

Other Gow-Mac Analyzers include:

GAS BLENDER — For quality control, oxygen or hydrogen burn-out and uniform quality of cylinder mixes and cascades.

"GAS MASTER" — For closely linked laboratory systems. Has all components in a single package.

GAS CHROMATOGRAPHY CELLS — Hot Wire and Thermistor Types

ON STREAM T/C CELLS — Hot Wire and Thermistor Types

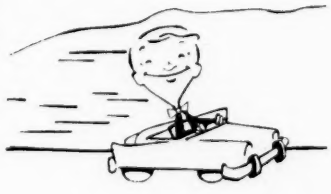
NEW CATALOG AVAILABLE — Call or write for Bulletin TC TH-12-57

Please address inquiries to Dept. IA

GOW-MAC INSTRUMENT CO.
100 Kings Road, Madison, N.J.
Telephone: FRontier 7-3450

Visit Booth 102—Natl. ACS Meeting San Francisco, Calif.—April 13 to 18

For more information circle **20** on inquiry card.



FOR SPEEDY INFORMATION

Slow down long enough to note there is a key number at the end of product and literature reviews and at the foot of each ad. To speed more information your way, circle the corresponding number on the inquiry card bound in this issue. If the card has already been used, simply write the key number, the date of issue, and your name and address on a postal card and send c/o our Reader Service Dept.

You're precisely correct

when you use

Fenwal Thermistor Temperature Controllers

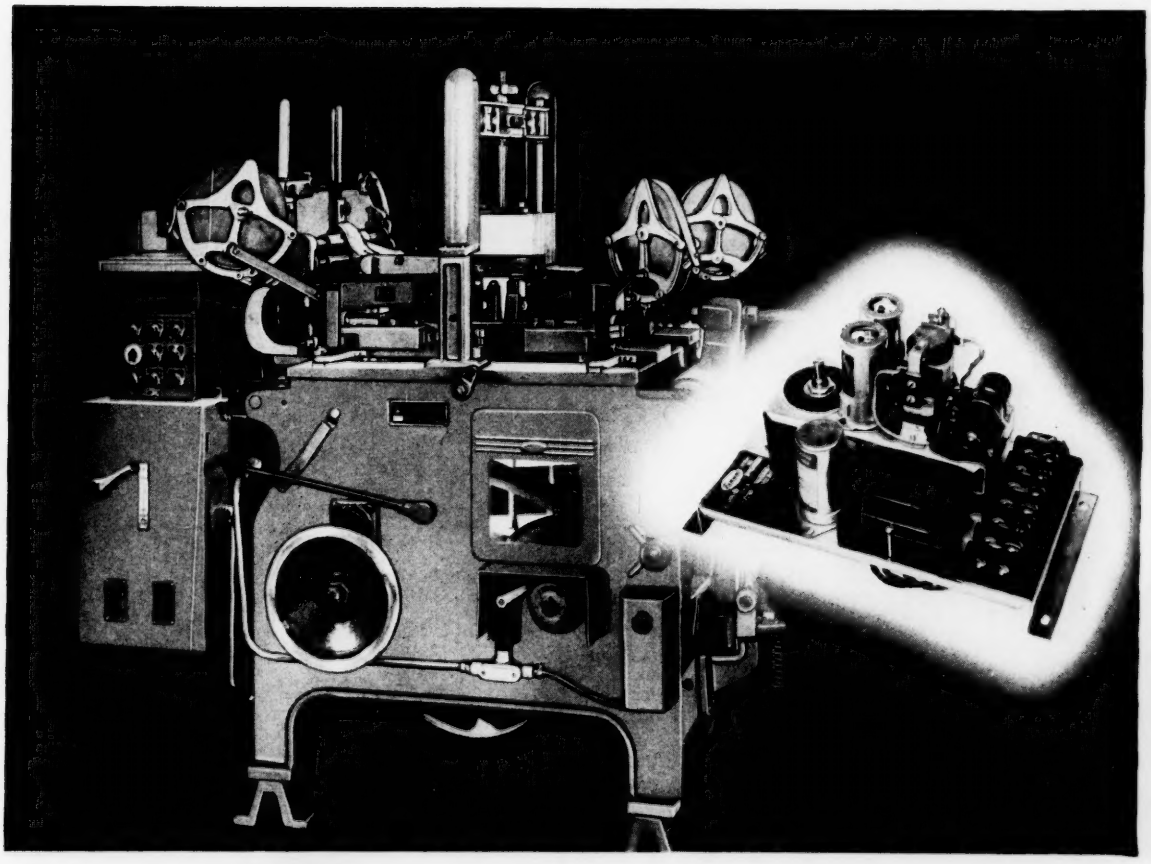
When we say "precisely" we mean control within .25% of range! Here's why — when temperature goes up, the resistance of the thermistor sensing element goes down — a unique property that makes very small temperature changes into large resistance changes. That means *quick, extremely precise temperature control!*

Small probes respond fast — can be installed nearly anywhere. Unbalanced bridge circuit design assures sensitivity and reliability. These are among reasons why one Thermistor Controller customer can report 0.08°F control. Why another reports over two years service with *no drift or set point variation!*

You can have remote control — as much as 200 feet — without ambient or lead length compensation problems. You can control 1 or 100 points, with or without indication. Versatile Fenwal Thermistor Controllers are adaptable to all kinds of applications. No matter what your need, you get *dependable precision with amazing stability.*

You'll want to have complete details on the new advance in precision temperature control at your fingertips, and we'll get it in your hands soon if you'll write us at Fenwal Incorporated, 363 Pleasant Street, Ashland, Massachusetts.

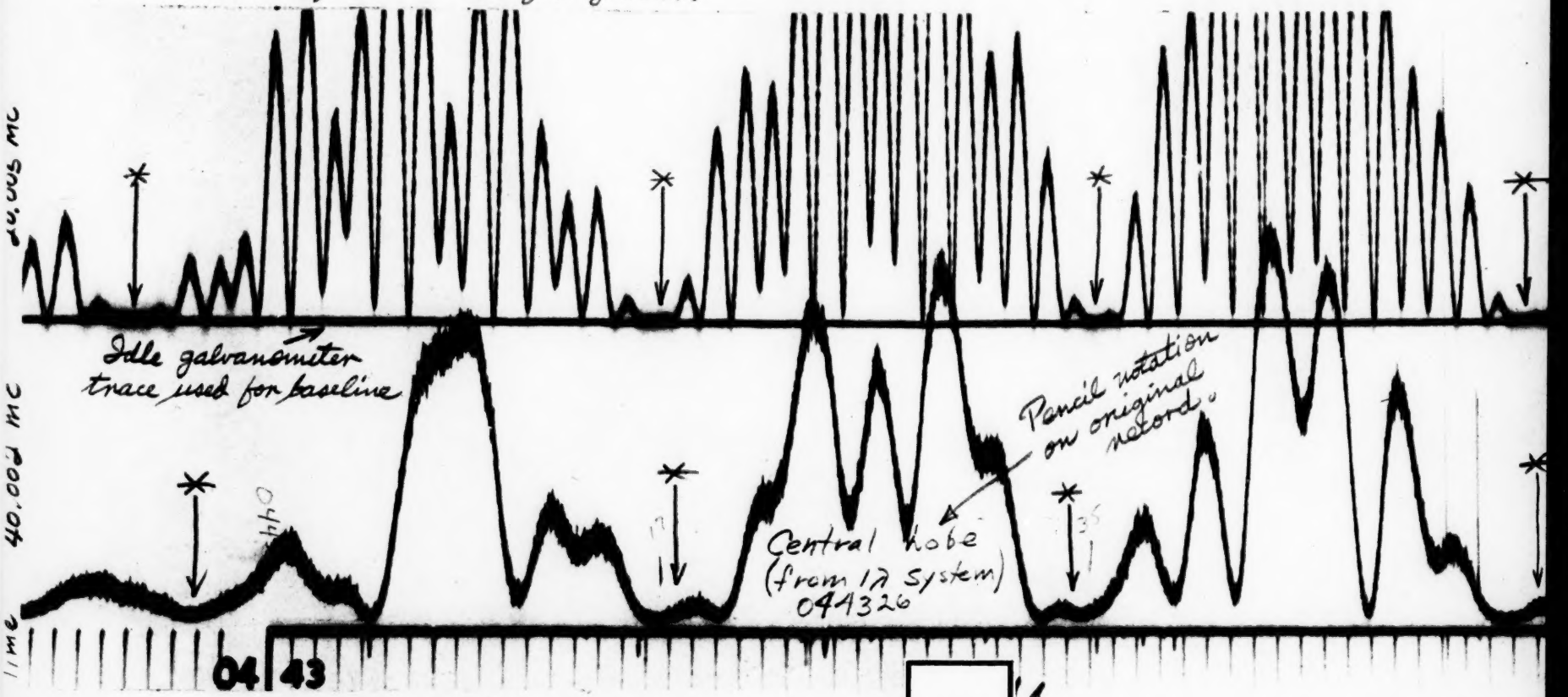
Here's a Thermistor Controller (Model 530) in a package forming machine. One Fenwal Thermistor probe in one corner plunger controls temperature at all four corners. A potentiometer on the control panel permits infinitely variable temperature range from 200 to 600 degrees. It eliminates a thermostat in each of the corner plungers, simplifies operation and maintenance — and assures uniformly high quality output. There are four standard temperature ranges for you to choose from: −100°F to 50°F; 0°F to 150°F; 100°F to 300°F; and 200°F to 600°F. Special ranges can, of course, be supplied in most cases.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

For more information circle **22** on inquiry card.

#2 This picture shows slightly less than one minute of a record perhaps 10 minutes long. It is a good interferometer record, though not quite as "pretty as #1. It has a very good record of WWV timing signals.



Timing "ticks" (seconds) from WW

this

* - Nulls in pattern of interferometer antenna (fine structure) are signal fading.

. The other lobes & nulls

The Visicorder has charted the orbit of Sputnik I

A Model 906 Honeywell Visicorder Oscillograph wrote this record of the signals from Sputnik I for the Department of Electrical Engineering at the University of Illinois at Urbana. The marginal notes are those of Edgar Hayden, the research associate who took the record.

Interferometer-type antenna systems (2 dipole elements 1/8 wave length above ground spaced several wavelengths along a north-south baseline) received the two signals for communications-type radio receivers. The beat oscillators generated audio output signals, a semi-conductor bridge curcuit rectified them, and the d-c output, filtered by an R-C network with a time constant of about .003 seconds, was used to drive the Visicorder galvanometers directly.

The Visicorder, teamed with the interferometer antenna, quickly established a record of the orbit of Sputnik I.

is a record of Sputnik I

The HONEYWELL VISICORDER is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis Honeywell Industrial Sales Office for a demonstration.

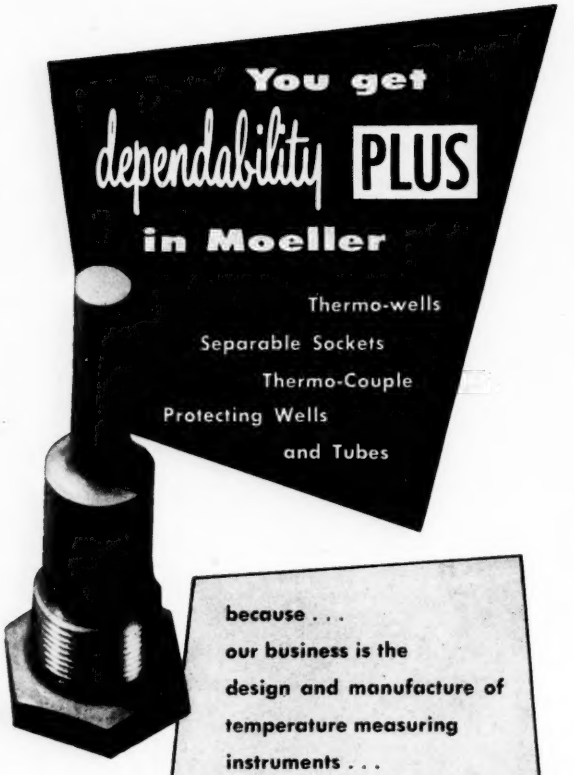
Reference Data: Write for Visicorder Bulletin

Minneapolis Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

MINNEAPOLIS **Honeywell**

Heiland Division

For more information circle **23** on inquiry card.



because . . .
our business is the
design and manufacture of
temperature measuring
instruments . . .
and has been since 1867.

Close to 90 years
of experience in this field
has made the name of
MOELLER the standard of
accuracy and reliability.

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precision products
made by Moeller
mail the coupon, today.

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18 N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Thermo-Wells, Separable Sockets, Thermo-Couple Protecting Wells and Tubes.

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FIRM

ADDRESS

CITY ZONE STATE

For more information circle **24** on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

New York Stock Exchange:

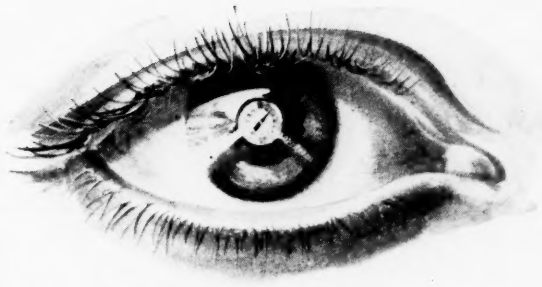
	Price Range For 1957-58 Thru Feb. 17, 1958 High	Low	Price As Of 2/17/58
ACF Industries	64 7/8	35 7/8	44 3/4
Aeroquip Corp.	31 5/8	16 7/8	17 5/8
Allis Chalmers	35 1/4	20 7/8	26
American Machine & Foundry	43 3/4	29 1/8	35 3/4
American Chain & Cable	64 1/4	35 3/8	44 3/4
American Machine & Metals	58 3/4	41	51
American Optical	38 1/4	30 3/4	37 1/2
American Tel. & Tel.	179 7/8	160	172 1/4
Beckman Instruments	47 3/4	20 1/4	21 7/8
Bell & Howell	50 1/2	36 1/2	46 1/2
Bendix Aviation	66 3/4	42	47 5/8
Boeing Airplane	61 1/8	29	36 1/8
Bullard	29 1/8	9 3/8	13 1/8
Bulova Watch	21	9 3/4	11 3/8
Burroughs	52 3/8	27 7/8	30 7/8
Carborundum	51 1/4	26 1/4	33 1/2
Cincinnati Milling Machine	30 1/2	25 5/8	32
Clevite	25 1/2	15 1/8	17 7/8
Columbia Broadcasting "A"	36 1/8	23 1/2	26 1/2
Consolidated Electrodynamics	54 3/4	25 1/8	29 1/8
Consolidated Electronics	35 1/2	18	20 5/8
Cornel Dubilier	27 1/2	12 1/2	14 1/4
Corning Glass	108 1/4	57 1/4	76 1/4
Curtiss-Wright	47 3/8	23 3/4	24 1/8
Cutler Hammer	64 3/4	36 1/2	42 1/4
Daystrom	47	27 1/2	30 3/4
Douglas Aircraft	91	50 5/8	60 1/2
Eastman Kodak	115	81 1/4	99 3/4
Eaton Manufacturing	64 1/4	38 1/2	42
Electric Auto Lite	40 3/8	24 1/2	27
Elgin Watch	14 1/8	5 5/8	9
Emerson Electric	34	22 1/8	33
Food Machinery & Chemical	65 1/4	42 3/4	51 3/4
Gamewell	36 1/2	20	22 3/4 - 23 1/2 (1)
Garrett	34	23 1/4	28 1/2
General Dynamics	68 5/8	46 3/4	61 3/4
General Electric	72 3/8	52 3/8	61 1/2
General Instrument	8 1/8	4	5 1/8
General Mills	69	36	64 3/4
General Precision Equipment	47 1/4	30 1/4	38 5/8
General Railway Signal	34	19 1/2	22 3/4 - 23 (2)
General Telephone	45 1/4	36 1/4	42 3/8
General Time	30 1/2	17 1/2	19 5/8
General Tire & Rubber	30 3/8	22 1/8	27
International Business Machines	376 1/2	270 1/2	331
International Tel.& Tel.	37 3/4	25 3/4	30 1/2
ITE Circuit Breaker	50 3/8	33	37 1/2
Lockheed Aircraft	57 1/8	26	40 3/4
Litton Industries	56 5/8	29 1/2	39 3/8
Magnavox	44	28 1/8	36 1/2
Minneapolis-Honeywell	131	73 1/2	82 1/2
Minnesota Mining & Mfg.	101	58	76 1/4
Motorola	51 3/4	35 3/4	39 1/8
Mallory	50 1/4	23 1/2	26 5/8
National Acme	60 1/2	40 1/2	46 1/4
National Cash Register	70 5/8	46 1/4	55 1/4
North American Aviation	39 1/4	20 1/8	29 7/8
Northrop Aircraft	26 1/8	15 3/4	23 7/8
Otis Elevator	49 1/2	38 3/4	47 1/2
Philco	18 3/8	11	14 1/2
Radio Corp. of America	40	27	33 3/4
Raytheon	24 5/8	16 3/8	23 1/8
Rheem Mfg.	21 1/4	10	12 1/8
Robertshaw Fulton	36 1/2	20 7/8	23 1/2
Reliance Electric	50 7/8	30 1/2	33
Sangamo Electric	39 3/4	29 1/4	33
Sperry Rand	26 1/8	17 5/8	19
Square D	35 3/4	19 1/8	21 7/8
Standard Coil Products	9 3/8	5 3/4	7 5/8
Starrett (L.S.)	85 1/2	57	57 3/4 - 60 (1)
Stewart-Warner	41 5/8	27 1/4	30 5/8
Sylvania Electric	46 1/4	29 1/4	35 3/8
TelAutograph	8 3/4	3 1/2	5 1/4
Texas Instruments	31 1/2	15 7/8	27 7/8
Thompson Products	69 3/4	46	45 1/2
Tung Sol Electric	37 1/2	21 3/4	24 1/4 - 24 1/2 (2)
Underwood Corp.	33 3/4	12 1/8	14 3/8
Union Carbide Corp.	124 1/2	90	90 1/4
United Shoe Machinery	45 7/8	30 3/4	37 5/8
Western Union	20 3/8	14 1/2	17
Westinghouse Air Brake	33 1/8	17 1/2	21 5/8
Westinghouse Electric	66 5/8	52 3/8	62 1/2
Worthington Corp.	66 1/2	45 1/8	47 1/4

(1) Not Traded , Bid-Asked
(2) Not Traded , Bid-Asked

American Stock Exchange:

	Price Range For 1957-58 Thru Feb. 17, 1958 High	Low	Price As Of 2/17/58
American Meter	34 1/8	26 1/8	30 1/2 - 31 1/4 (1)
Aro Equipment	22 7/8	13 1/4	14 7/8

Continued on page 394



What you read is right

The new, patented Maxivision dial on American Bi-Metal Thermometers eliminates the perspective effect of usual pointer-above-dial construction. No parallax! Readings are sure, sharp and accurate – exact working temperatures are always right before your eyes. It is a two-level dial. A raised outer ring, set close to the cover glass, carries the graduations. The index type pointer is on the same plane as the outer ring, with the numerals on a lower level.

What you read is right when American Bi-Metal Thermometers with anti-parallax Maxivision dial are installed at important check points on your processing facilities. Mounting styles, dial sizes, temperature ranges and stem lengths are available to meet the most exacting requirements. Let your nearby industrial distributor help you select the best combination for each location.

American Bi-Metal Thermometer with Maxivision Dial. Suitable for indoor or outdoor service.

MAXWELL MM&M MANNING & MOORE INC. TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

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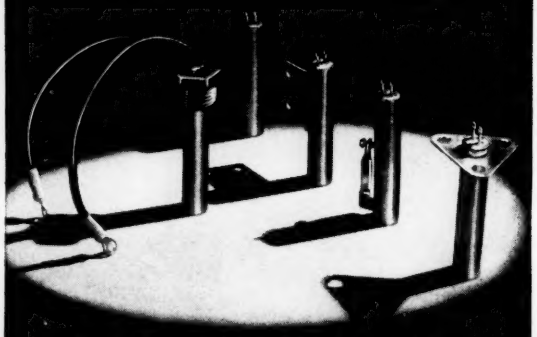
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

A2-58

For more information circle **25** on inquiry card.

If You Want a Thermostat That's Rugged...



that operates dependably at settings as low as −40°F. and as high as +300°F....

G-V's C8 Series of hermetically sealed electrical thermostats is specially designed to meet the difficult operating conditions of electronic and aircraft applications. Operating points, regardless of settings, are not changed by exposure to temperatures ranging from −100°F. to +300°F. Shocks up to 150g for 3 milliseconds, vibration of 25g up to 1000 cps, and vibration of 10g up to 2000 cps do not damage these thermostats nor change their setting.

Write for complete technical and application data

G-V CONTROLS INC.
60 HOLLYWOOD PLAZA • EAST ORANGE, N. J.

For more information circle **26** on inquiry card.

American Stock Exchange

Continued from page 392

Belock Instrument	12 5/8	6 1/4	8 1/2 - 8 5/8 (2)
Benrus Watch	8 1/2	6	6
Breeze Corp.	6 3/8	4 5/8	5 1/2
Barry Controls	12 3/4	5 7/8	5 3/4
Clark Controller	31	13 3/8	16 7/8
Clarostat Mfg.	5	2 1/2	3 1/8 - 3 3/8 (3)
Clary Corp.	4 7/8	2 1/2	4
DuMont Laboratories	6 1/8	3	3 7/8
Dynamics Corp. of America	7 5/8	2 1/2	4
Electronics Corp. of America	12 7/8	5 1/2	6 3/4 - 7 1/4 (4)
El- Tronics	3 7/8	1 1/2	2 3/8
Fairchild Camera & Instrument	26 7/8	16	26 3/4
...ron Union	20 3/4	16 1/2	16 1/2 - 17 1/4 (5)
Hazeltine Corp.	44 1/2	29 3/4	33 7/8
International Resistance	6 1/8	3 5/8	4
Lear Inc.	8 3/4	4	5 3/4
National Research	26 5/8	12 1/8	14 1/8
Neptune Meter	33 1/2	18 5/8	21 1/2
New Haven Clock	9/16	1/8	1/4 - 3/8 (6)
Norden-Ketay	11 3/4	3	3 1/2
Nuclear Corp. of America "A"	3 1/4	3/4	1 1/2
Pneumatic Scale	25	18	22 1/4
Servo Corp. of America	8	3 3/4	4 5/8
Servomechanisms	12 5/8	6 1/8	7 1/4
Wallace & Tiernan	33 7/8	23 1/4	25 1/4
Waltham Prec. Instrument Co.	2 1/4	5/8	1 1/8

1 thru 6 - Not Traded. Bid - Asked

Over-The-Counter

	Quotation as of 2/17/58	
	Bid	Asked
Aerovox Corp.	3 1/2	4
Aircraft Radio Corp.	20 1/2	21 1/2
Argus Corp.	16 3/4	17 1/2
Eitel-McCullough Co.	28	29
Electronics Associates	33 1/4	34 3/4
Erie Resistor Corp.	7 5/8	8 1/8
G.M.Giannini	13 7/8	14 1/2
Liquidometer Corp.	5 3/4	6 1/2
W.L.Maxson	6	6 1/2
Penn Controls, Inc.	14	15
Speer Carbon, Inc.	20 1/4	22
Sprague Electric	29 3/4	31 1/4
Taylor Instrument	29 1/4	30 1/2
Telecomputing Corp.	4	4 1/2
Topp Industries	8 1/8	8 3/4
Varian Associates	15	16 1/2
Vitro Corp. of America	17	17 7/8

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, RHODE ISLAND, U. S. A.

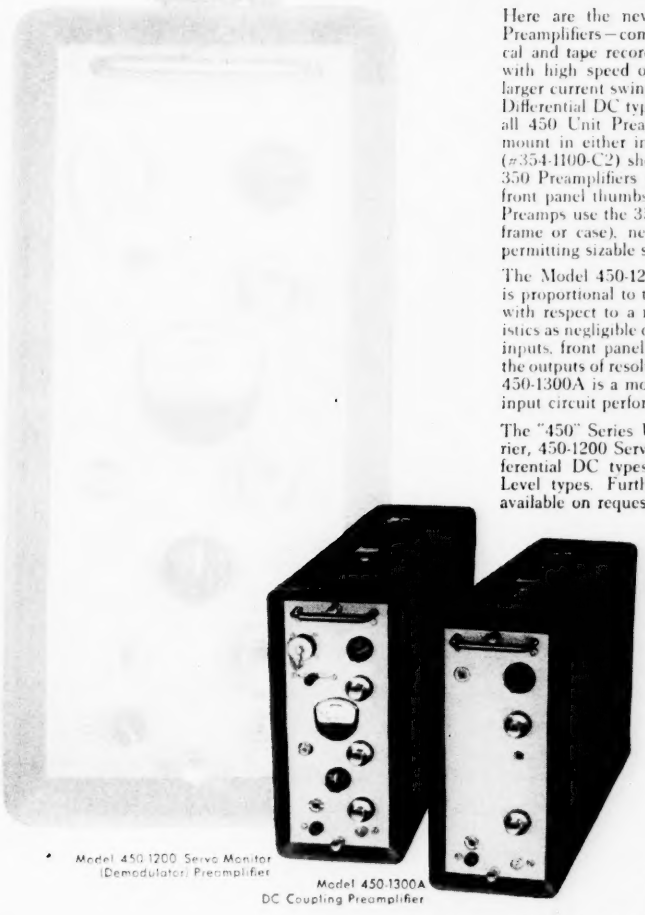
For more information circle **27** on inquiry card.

two more UNIT PREAMPLIFIERS
in the new
SANBORN "450" SERIES

Here are the newest of the recently introduced Sanborn "450" Series Unit Preamplifiers—compact, lightweight, self-contained instruments for use with optical and tape recorders, wide band 'scopes, panel meters, computers, etc. (For use with high speed optical galvanometers at frequencies above 500 cps, requiring larger current swings, a transistor output amplifier is built into the 450-1800A True Differential DC type and available as optional equipment on other 450's.) As with all 450 Unit Preamplifiers, the new Servo Monitor and DC Coupling models mount in either individual portable cases or in the four-unit 19" module frame (#354-1100-C2) shown. The *450* designation refers to *unit packaging* of Sanborn 350 Preamplifiers and Power Supplies in individual 450 cases. Loosening two front panel thumbscrews allows quick, simple interchangeability. Since *all* "450" Preamps use the 350-500 Power Supply (which remains in place at the rear of the frame or case), new requirements necessitate only additional *Preamplifier* units, permitting sizable savings in equipment investment.

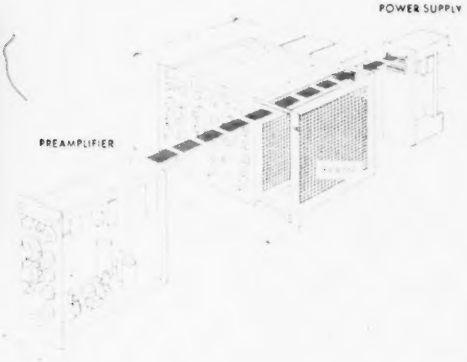
The Model 450-1200 is a phase-sensitive demodulator, whose DC output voltage is proportional to the in-phase (or 180° out-of-phase) component of an AC signal with respect to a reference. Precision measurement is realized by such characteristics as negligible quadrature signal error, provision for floating signal and reference inputs, front panel VTVM for accurate calibration signals. The 450-1200 accepts the outputs of resolvers, synchros, differential transformers and other transducers. The 450-1300A is a moderate gain, balanced input—balanced output DC amplifier. Its input circuit performs equally well with single-ended or balanced signals.

The "450" Series Unit Preamplifiers presently include the Model 450-1100 Carrier, 450-1200 Servo Monitor, 450-1300A DC Coupling and 450-1800A True Differential DC types. Following these will be "450" Series Logarithmic and Low Level types. Further data and application information on present models is available on request.



Model 450-1200 Servo Monitor (Demodulator) Preamplifier

Model 450-1300A DC Coupling Preamplifier



MAJOR SPECIFICATIONS

MODEL 450-1200 SERVO MONITOR PREAMPLIFIER

Sensitivity: 5 mv (in phase) produces 1 volt at output jack under maximum output load conditions
Input Impedance: Signal 100k
Reference 12.5k for 15 volts, 55k for 120 volts
Frequency Response: 3db down at 20% of carrier frequency filter position
Carrier Frequency Filter: Selected by a switch (three positions)
Low 60 cycles
Med 400 cycles
Hi 1000 cycles (5000 cycles optional)
Reference Voltage: Internal selection accepts voltages from 15 to 120 volts
Quadrature Rejection: Ratio better than 100:1
Maximum permissible quadrature before overload indicator lights is twice full scale (in phase)
Calibrate Voltage: 10 millivolts internal (set by meter on panel)
Drift: Less than 0.1% of full scale per hour
Preamplifier Output Jack: ±3 volts available into 2.2k minimum load resistance. Output appears across two cathodes at approximately ground potential
Rear inputs and overload indicator lights are included
Output Impedance: 1k
Overall Linearity: ±¼%
Power Requirements: 115 volts, 50-400 cycles, approximately 35 watts

MODEL 450-1300A DC COUPLING PREAMPLIFIER

Sensitivity: 50 mv produces 1 volt at output jack under maximum output load conditions
Input Impedance: 5 megohms each input side to ground
Input: Single-ended or push-pull
Preamplifier Output Jack: ±3 volts into 2.2k minimum load resistance. Output is balanced and appears across 2 cathodes at approx. ground potential
Output Impedance: 1k
Drift: Referred to input 2 mv /hr. line voltages change less than 10%
Frequency Response: 0-20kc
Calibration: 100 millivolts internal
Linearity: ±¼%
Rear inputs included

See the new "450's" and other Sanborn equipment at Booth 3601-3603 I. R. E. Show

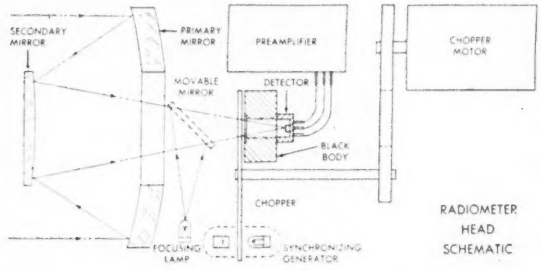
SANBORN COMPANY
INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

For more information circle **28** on inquiry card.

briefs

Industrial Radiometer

OptiTherm Radiometers are merely aimed at target objects; they do not require contact. They can thus be used in the temperature-measurement of remote and inaccessible objects for which conventional thermometers and thermocouples cannot be used . . . Infrared radiation



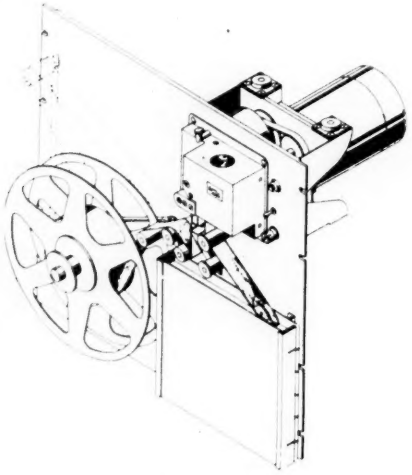
is electromagnetic energy emitted by objects because of the thermal agitation of their molecules. Below 1000°C most of this energy is in the infrared spectrum, occupying the region between light and microwaves. By measuring the infrared radiance of an object of known surface characteristics, an accurate determination can be made of its temperature.—(*From new 4-page Bulletin* 1210, *Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.*)

For this literature circle **201** on inquiry card.

Super-Speed Punched Tape

Operating Speed: 240 codes per second. Code characteristics: Models available for perforating either 5, 6, 7, or 8 level tapes.

Code Interposer Magnets: 100 ma, 0.37 Henries with armature closed, 0.19 Henries with armature open, 250



ohms resistance, 0.76 milliseconds minimum time constant. Feed Magnets: 120 ma, 0.75 Henries with armature closed, 0.40 Henries with armature open, 310 ohms resistance, 1.3 milliseconds minimum time constant. Magnet Insulation: 1000 volt DC test 400 volt maximum peak AC signal.

Synchronization signals: 2-5 volts, $\frac{1}{4}$ millisecond duration from 2000 ohm source. Individual reluctance pickups are provided to indicate duration of punch and feed cycles. Each pick-up provides two signals of opposite polarity which bracket the desired excitation intervals.—(*From 12-page Bulletin, Soroban Engineering, Inc., Box 1717, Melbourne, Florida.*)

For this literature circle **202** on inquiry card.

Differential-Pressure Flowmeter

The most practical method yet devised for metering fluid flow rates, subject to the limiting conditions outlined below, consists of putting a restriction, called the primary device, inside the pipe and measuring the difference in pressure across the primary device . . . Primary devices, or differential producers, are available in three principal forms: (1) Venturi Tube . . . (2) Flow Nozzle

LIQUID FLOW	G(gph)	$= d_1^2 F_a F_r \sqrt{h}$	(Equation 1)
STEAM FLOW	W(lbs/hr)	$= d_1^2 F_a F_r \sqrt{hP}$	(Equation 2)
AIR OR GAS FLOW	Q(scfh)	$= d_1^2 F_a F_r F_y F_t F_g \sqrt{hP}$	(Equation 3)

. . . (3) Orifice Plate . . . Pressure recovery characteristics of the primary devices are compared on chart.

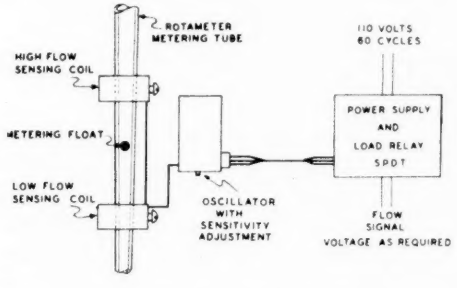
The eccentric orifice is sometimes used to provide unobstructed flow for gases carrying liquid condensates or for liquids carrying small quantities of undissolved solids. When used with liquids carrying undissolved gases or vapors, the eccentric orifice is located at the top of the pipe. Segmental orifices are designed for use in fluid streams carrying a high percentage of undissolved solids, to prevent the accumulation of heavy material which settles out.

Experimental data for eccentric and segmental orifices are very limited; consequently metering accuracies comparable to concentric orifices cannot be expected.—(*From new 22-page Bulletin* 1607, *including "Flow Meter Calculations," The Bristol Co., 113 Bristol Rd., Waterbury 20, Conn.*)

For this literature circle **203** on inquiry card.

Electronic Flow Alarm

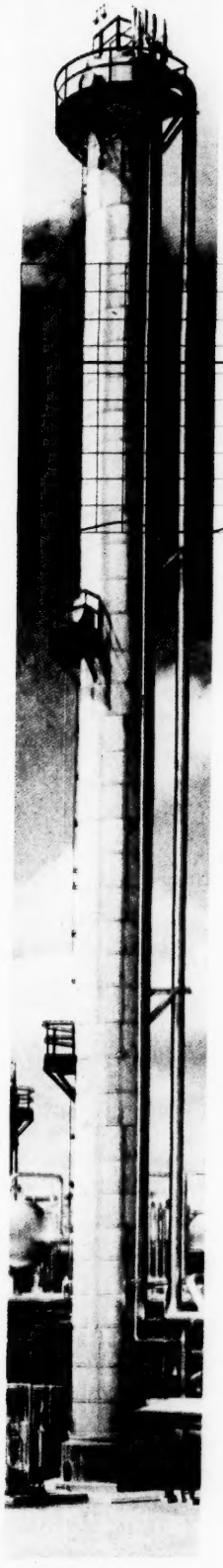
When the metal rotameter float enters the field of the sensing coil, it abruptly changes the resonant frequency of the oscillator circuit, oscillation ceases, and current falls off allowing a load relay to drop out to actuate an alarm or perform any other annunciator or control func-


ROTAMETER METERING TUBE
110 VOLTS 60 CYCLES
HIGH FLOW SENSING COIL
METERING FLOAT
POWER SUPPLY AND LOAD RELAY SPDT
LOW FLOW SENSING COIL
OSCILLATOR WITH SENSITIVITY ADJUSTMENT
FLOW SIGNAL VOLTAGE AS REQUIRED

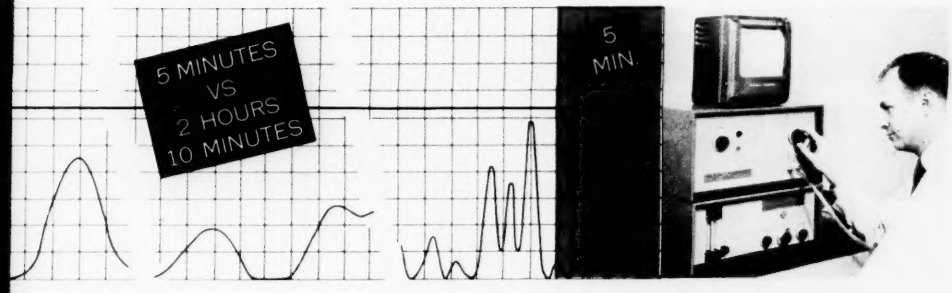
tion. Once the load relay has dropped out, it can be reset by means of an external reset pushbutton only when the float has moved out of the sensing coil field.—(*From new 4-page Bulletin* 165, *Brooks Rotameter Co., P.O. Box 432, Lansdale, Penna.*)

For this literature circle **204** on inquiry card.

Continued on page 403



Faster analyses...
assure faster instrument payout



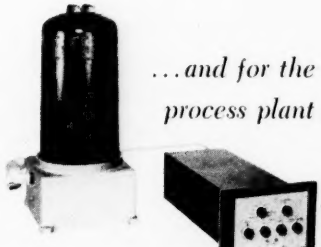
26 runs through n-pentane
in the same time
usually required
for one run through C_{10}

CEC's versatile laboratory chromatograph

Easily operated by untrained help, CEC's rugged 26-201A guarantees speed and superior reproducibility. An *exclusive* Thermostatted Pre-Cut Column eliminates any chosen portion of the heavier sample fraction from the analysis of a complex mixture—thus reducing the analysis time from 130 minutes to 5 minutes!

Other CEC exclusives are a capillary sampling accessory which permits obtaining a representative sample from a high-pressure source, thus eliminating the use of fragile hypodermic syringes. Also, a heated sample vaporizer which vaporizes liquid-samples and assures a sample reproducibility of better than ±0.5%, without reliance on operator skill. Sensitivity in parts-per-million and unique, self-contained modular construction offer maximum flexibility, maximum economy.

For complete information, contact your nearest CEC Field Office, or write for Bulletin CEC 1831A-X4.



...and for the process plant...

CEC's reliable process chromatograph

For automatic, continuous remote control and for the recording of multiple streams, no instrument can surpass the 26-202's simplicity, precise reproducibility, and precise regulation. Sample volumes are reproducible to better than ±0.5%, temperatures are controlled to within less than 1°F. Design considerations permit the analyzer to be situated at least 500 feet from the control unit. Analyzer is constructed to meet the requirements of Class I, Group D, Division 1 hazardous locations. *Write for Bulletin CEC 1836-X22.*

NO MATTER WHAT YOUR PROBLEMS ARE...

Simply state your needs—CEC's application and system engineers are available to design and install complete systems for any application requirements. *Contact your nearby CEC Field Office.*

Analytical & Control Instruments Division

Consolidated Electrodynamics

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OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **29** on inquiry card.

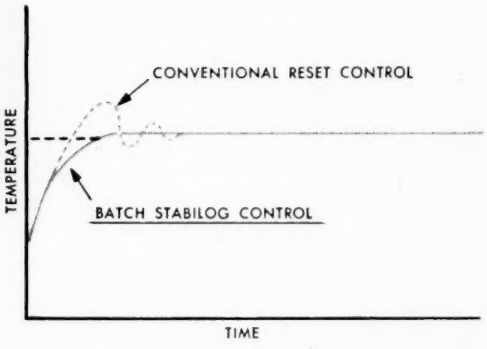
Faster, safer start-ups for Batch Processes

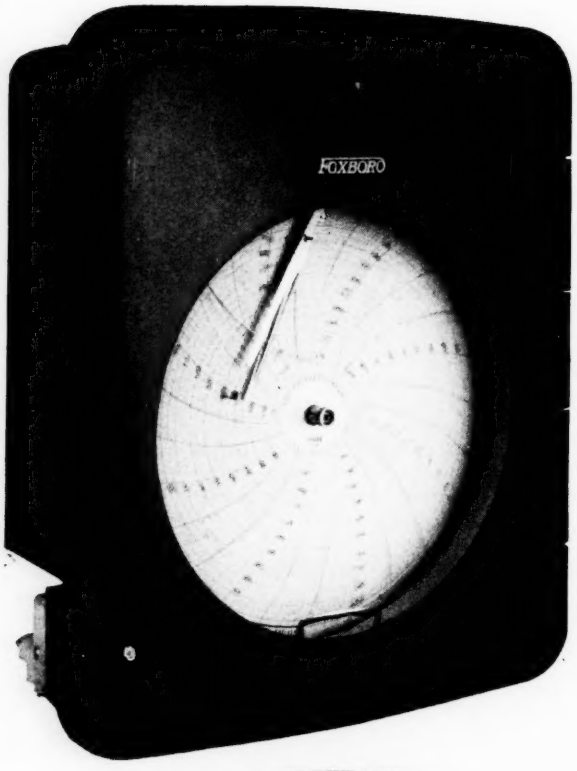
no overshoot

no spoilage

no undesirable side-chain reactions

no explosion hazards





That's right! You can get rid of costly, dangerous temperature "overshoot" problems in batch processing! The Foxboro Batching Controller solves them. This versatile Controller brings temperature up to control point fast . . . stops it "on the nose" . . . keeps it there throughout the holding period. What's more, this fast "no overshoot" control doesn't compromise *holding* control . . . settings are made separately, for optimum results in both periods.

Here's how the Controller works. It starts the operating cycle by feeding maximum heat to the batch . . . brings temperature up fast. At desired distance below control point, adjustable "braking" action automatically slows temperature rise . . . levels it off smoothly at the control point. Simultaneously, the "balancing" action begins . . . holds control point setting exact . . . restores it even when upsets occur. At shut-down of process, the Controller automatically resets itself . . . ready for another precise performance.

Send for information today. (For batch operations requiring *controlled rate of rise*, write for data on Foxboro Cam-Set and Time-Cycle Controllers.)

The Foxboro Company, 143 Norfolk St., Foxboro, Mass., U.S.A.

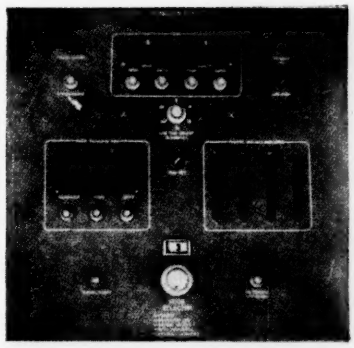
FOXBORO
REG. U. S. PAT. OFF.

CREATIVE INSTRUMENTATION
for Process Automation

For more information circle **30** on inquiry card.

Kybernetes data handling equipment proven 99.7% reliable by 37,851* hours of in-plant performance!

* covering the 12 installations made during the past year.



Unmatched accuracy and reliability are achieved and sustained in the Kybernetes Data Handling System by the incorporation of advanced, fully proven techniques. The Kybernetes System provides a new, all electronic concept for the acquisition of process or test information for logging, monitoring and computing. This equipment is designed for accuracies of 0.1% for all inputs, including non-linear types, over extended periods of operation.

The Kybernetes all electronic approach to data handling provides the most direct means of digitizing low level inputs. Discrete counts, proportional in number to the magnitude of the input variables, are stored in digital form ready for direct reading into the printer or display panel. Complex analog to binary encoding and subsequent binary to digital decoding are completely eliminated.

Components having marginal operating characteristics are eliminated from Kybernetes' Data Handling Equipment, which contains no servos, stepping switches or other mechanical operations.

FEATURES OF KYBERNETES DATA SYSTEMS INCLUDE:

A — Provision to record sequential or simultaneous readings of any quantity of inputs.

B — Chopper amplifier with exceptional frequency response, linearity and gain stability as well as high noise rejection and true isolation of input and output circuitry.

C — Individual, hermetically sealed plug-in relay switching providing reliable long term commutating of input signals.

D—Specially developed linearization techniques whereby the generated comparison voltage is characterized to conform exactly to the individual non-linear characteristics of the different types of variables.

E—Plug-in, hermetically sealed components to conform to Class I, Division II requirements for semi-hazardous areas and to provide for ease of maintenance and service.

ON REQUEST: Authoritative Technical Bulletin 108a fully describes latest logging, monitoring and computing equipment. Write for free copy.

KYBERNETES®

Data Handling Equipment for Industry
logging/monitoring/computing

THE KYBERNETES CORPORATION 9 East 40th Street, New York 16, N. Y. Division of Self Winding Clock Co., Inc.

For more information circle **31** on inquiry card.

NEW..ALL TRANSISTOR

the most versatile...most sensitive direct writing oscillograph ever available

combining all these features!

- ★ stable d-c sensitivity of one microvolt per mm
- ★ true differential input
- ★ high input impedance
- ★ response to beyond 150 cps.
- ★ reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all amplifiers
- ★ deflection time less than 2 milliseconds
- ★ fixed precision calibration
- ★ instant warm-up
- ★ precision source for d-c and 400 cycle excitation, self-contained
- ★ zero suppression, twenty times full scale, both directions

and all in only 33¼ inches of rack space for eight channels!

Using Offner developed transistor circuits which have been time-tested in over two years of service, in hundreds of channels of Offner Dynograph medical equipment, the Offner *Transistor* Dynograph is now first made available to industrial users as a *time* and *service* proved instrument, which we believe superior in practically every important respect to any other direct-writing oscillograph.

The Type R incorporates the following units:

Type 482 Dual Channel Transistor Power Amplifier itself providing sensitivities from 10 MV to 50 volts per cm, with a stability impossible with conventional amplifiers. The high performance of the Type 482 is made possible only by the Offner-developed transistor circuits employed*. Zero suppression and internal self-calibration are incorporated. The Type 482 may be employed without preamplifier when its sensitivity is sufficient, and differential input is not required.

Type 481 Preamplifier, incorporating the circuit principles of the Type 190 Data Amplifier*, provides zero-drift amplification of signals down to the microvolt level, and permits a sensitivity of up to ten microvolts per cm to be realized. The Type 481 provides true differential amplification with infinite rejection of d-c common signals. Gain stability and linearity are so nearly perfect that zero suppression may be employed *after* the preamplifier, permitting considerable simplification of operation in many applications. The Type 481 also serves as a phase sensitive demodulator for reluctance gage and other a-c bridge applications.

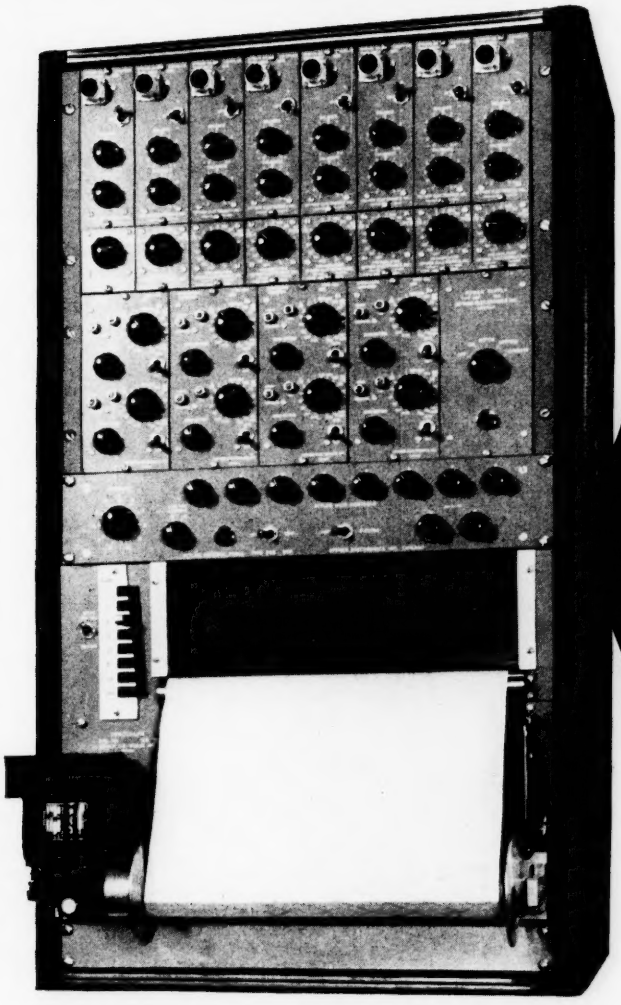
**Patents granted and Pending*

see it at the IRE show . . . Booth No. 3051

For more information circle **32** on inquiry card.

DYNOGRAPH

see it at the IRE show Booth No. 3051



THE OFFNER TYPE R TRANSISTOR DYNOGRAPH

Type 9800 Series Input Couplers plug into the Type 481 Preamplifier units, and provide all necessary bridge balancing facilities, etc. A variety of standard panels are available for strain gage, reluctance gage, LVDT, and d-c input applications. Special couplers will be provided for applications not provided by standard couplers.

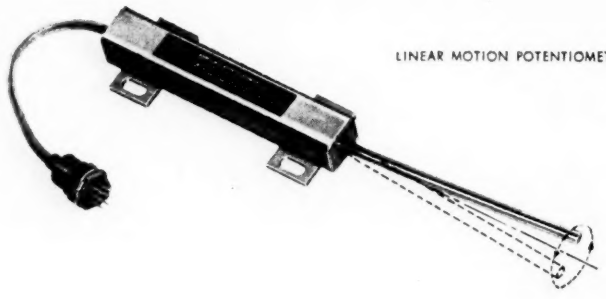
Type 504/506W Dynograph uses the time-proved rugged and accurate low-resistance, high torque Dynograph element. The uniformity of response of the Dynograph units permits a frequency response substantially flat to beyond 150 cps to be now obtained, using the Type 482 Power Amplifier as driver. The Type 504 Paper Drive employs the exclusive Offner zero-weave drive principle*. Quick-change gear box provides eight speeds, one to 250 mm/sec; electrical speed change to mm/*minute* available as optional feature. Writing media available are curvilinear ink or electric; rectilinear heat or electric. Writing media may be interchanged in a few moments time.

Type 382 Power Supply provides all voltages for all amplifiers, and in addition a highly stable source for d-c excitation of strain gage bridges, and a stable source of 400 cps at 6 volts for operation of reluctance gages, LVDT's, and strain gage bridges when a-c excitation is desired.

OFFNER ELECTRONICS INC.

5326 N. Kedzie Avenue, Chicago 25, Illinois

For more information circle **32** on inquiry card.



LINEAR MOTION POTENTIOMETERS

ACCELEROMETERS

PRESSURE TRANSDUCERS

1355 PROVED POTENTIOMETER INSTRUMENT DESIGNS ---READY TO SAVE YOU TIME AND MONEY

Here are 3 of our 1355 ways to help you avoid costly "specials"... ready-made answers to thousands of problems in measuring linear displacement, pressure and acceleration. Bourns may have precisely the model you need — or one that can be quickly modified to fit your requirements.

More than 10 years of experience in design, development and manufacturing back up the instruments you buy from Bourns. These precision wirewound potentiometer instruments have proved their quality repeatedly in the nation's top missile and aircraft systems.

Whether your needs are standard or special, large or small, military or industrial . . . it will pay you to check Bourns *first*.

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Laboratories, Inc.

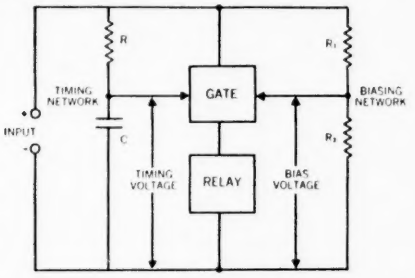
P.O. Box 2112 • Riverside, California

ORIGINATORS OF TRIMPOT,® TRIMIT® AND POTENTIOMETER INSTRUMENTS

For more information circle **33** on inquiry card.

Transistorized Time Delay Relay

The Tempo Time Delay Relay is an all-electronic unit utilizing transistors and RC time-constant circuit elements . . . Two inputs, timing and biasing, control the gate which is in series with the relay coil . . . When the timing voltage equals the bias voltage, the gate triggers and the relay is actuated . . .

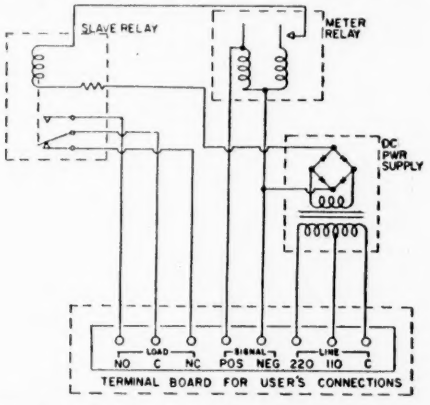


There are two auxiliary circuits in the gate, designed to provide extremely fast recycling. One circuit forcibly discharges the timing capacitor immediately upon relay actuation at the end of the delay period, providing a recycle time of 10 milliseconds maximum. The other circuit causes a low impedence to be seen by the capacitor if the operating voltage is removed before the end of the delay period—under this condition, the recycle time will not exceed 1/50th of the nominal delay time for most models.—(*From new 4-page Tech. Data 1357, Tempo Instrument Inc., 240 Old Country Rd., Hicksville, N. Y.*)

For this literature circle **205** on inquiry card.

Contact Meter Control

The most important feature of the "Versatrols" is that once meter-relay contacts "make" and do one of the things mentioned, the contacts lock and hold until reset manually. Shown is a high limit Versatrol (meter-relay contacts "make" with increasing current or voltage signal). For



low limit (contacts " make" with decreasing signal), action is the same but polarity at the Versatrol DC power supply is reversed so that the meter locking coil causes contacts to lock in a downscale direction (instead of upscale as with high limit).—(*From new 12-page Bulletin 106, Assembly Products, Inc., 75 Wilson Mills Rd., Chesterland, Ohio*)

For this literature circle **206** on inquiry card.

INSTRUMENT ENGINEERS . . .

need a small valve

on

- GAS ANALYZERS
- TEST STANDS
- AIR GAUGING EQUIPMENT
- GAS CHROMATOGRAPHY
- HIGH VACUUM EQUIPMENT
- GAS TRANSMISSION CONTROL PANELS
- AUTOMOTIVE TEST BENCHES
- OTHER INSTRUMENTATION APPLICATIONS

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Feature quick, flip-of-the-handle action for positive vacuum-tight shut-off. Helium leak tested. Molded nylon handles come in colors for coding instrument operations. Available in brass or 303 SS for 200 psi service in ⅛", ¼" and ⅜" sizes.

or reverse flow check

670 SERIES CHECK VALVES

Feature extremely effective leak-tight seal, exceptional flow characteristics and low-cost. Synthetic rubber seats and stainless steel springs give maximum corrosion resistance. Available in brass or 303 SS in ball and piston types for 5000 psi service in sizes ⅛" through ½"

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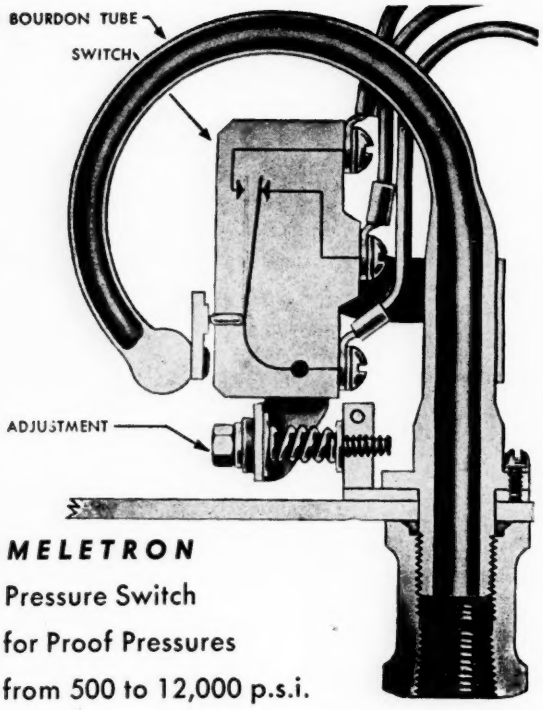
Englewood, New Jersey

For more information circle **34** on inquiry card.



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To get complete operating characteristics and specifications ask for bulletins 302 to 382.

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PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

For more information circle **35** on inquiry card.

BRIEFS—CONTINUED

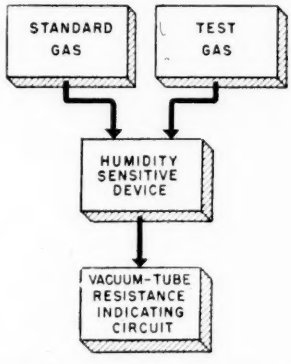
Weldable Strain Gages

The high output obtainable with the weldable gage is due to the high allowable input voltages which are possible . . . This high allowable input voltage with a relatively low resistance bridge means high output power is available to drive insensitive instrumentation or for measuring low strains . . . Normal installation of the weldable gage requires only that the surface be conductive, reasonably clean and smooth. The gage should be aligned in the direction of the desired strain measurement. Spot weld beads must be formed over the entire length of the gage, close together and close to each side of the tube.—(*From new 4-page bulletin, Micro-Test, Inc., 657 N. Spaulding Ave., Los Angeles 36, Calif.*)

For this literature circle **207** on inquiry card.

Water Vapor Indicator

The resistance of a given hygroscopic film is independent of the gases other than water vapor with which the film is in contact, and depends only on the amount of water contained in a unit volume . . . If a sample of gas, such as oxygen, of known water content per unit volume is passed over the film, it will assume a certain resistance.



If a second sample of gas of unknown water content is then passed over the film, the resistance will usually be different, but it may be restored to its original value by compressing or expanding the second sample until it contains the same quantity of water per unit volume as the first sample.—(*From new 8-page Bulletin 2301, American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.*)

For this literature circle **208** on inquiry card.

Vapor Pressure Recorder

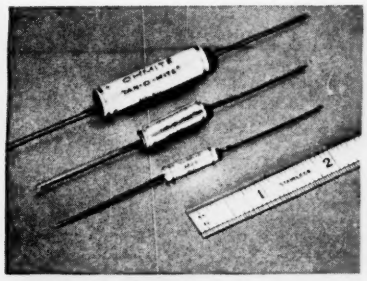
The Model 1158 Hallikainen-Shell Vapor Pressure Recorder is used to record proportions of binary mixtures of liquefied petroleum gases in a process stream . . . A liquid sample passes through the instrument continuously and reaches equilibrium with its saturated vapor phase in the vaporizing chamber, at which point the vapor pressure is measured by a Moore pressure transmitter . . . The level control system consists of an oscillator amplifier, an electro-pneumatic relay and a pneumatic valve. The oscillator is a tuned plate grid circuit; the grid circuit is crystal controlled at 7 mc/s. The amplifier is a high gain twin triode stabilized with current feedback. A Swartwout transducer or relay is connected to the plates of the tube.—(*From new 4-page Bulletin "Continuous Vapor Pressure Recorder," Hallikainen Instruments, 1341 Seventh St., Berkeley 10, Calif.*)

For this literature circle **209** on inquiry card.

NEW OHMITE®

HIGH STABILITY
FOR —55°C to + 85°C OPERATION
HIGH CAPACITANCE
SUBMINIATURE SIZES
LONG SHELF LIFE

"TAN-O-MITE®" TANTALUM CAPACITORS

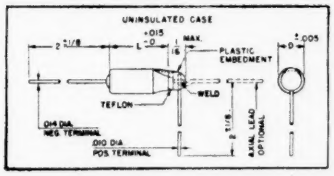


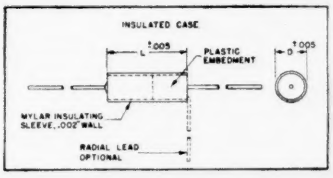
SERIES TW WIRE-TYPE TANTALUM CAPACITORS

These new subminiature, wire-type units feature greater capacitance per unit volume, lower leakage current and power factor, and small capacitance drop at extremely low temperatures as compared to other types of electrolytics. Ultrasmall for low-voltage DC transistorized electronic equipment, these new tantalum capacitors have *high stability, high capacitance, long shelf life, and excellent performance* under temperature extremes of—55°C to + 85°C. Available in eight subminiature sizes; 0.1 to 80 mfd. over-all capacitance range.

SIZE	UNINSULATED		INSULATED	
	D (inches)	L (inches)	D	L
*T	.075 (5/64)	.156 (5/32)	.082	.203
*S	.075 (5/64)	.187 (3/16)	.082	.234
*M	.095 (3/32)	.172 (11/64)	.100	.218
*A	.095 (3/32)	.250 (1/4)	.100	.312
*B	.125 (1/8)	.312 (5/16)	.134	.375
C	.125 (1/8)	.500 (1/2)	.134	.562
D	.125 (1/8)	.625 (5/8)	.134	.687
E	.125 (1/8)	.750 (3/4)	.134	.812

Smallest size is .075 (5/64) x .156 (5/32) inches; the largest is .125 (1/8) x .750 (3/4) inches. Five stock sizes (*) are available in a wide range of capacitances and voltages. Units insulated with a tough Mylar® plastic sleeve can be furnished. *Write on company letterhead for Bulletin 148B.*





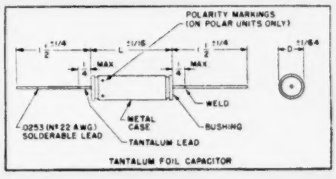
SERIES TF FOIL-TYPE

These capacitors are tantalum foil, electrolytic units designed for low voltage AC and DC applications where small size, top performance, and stability of electrical characteristics are required. Units feature unusually long shelf and operating life.

CASE SIZE	D*	L*
J	3/16"	1 1/16"
K	9/32"	7/8"
L	3/8"	1 7/16"

**Add 1/16" to L and 1/64" to D when insulating sleeve is used.*

Three sizes now available; .25 to 140 mfd. over-all capacitance range. Standard tolerance is ±20%. Working voltage up to 150 volts. Polar and nonpolar units are available. *Bulletin 152.* Design and construction meet military specification MIL-C-3965, paragraph 3.3.



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RESISTORS • RELAYS • TAP SWITCHES
RHEOSTATS • TANTALUM CAPACITORS
VARIABLE TRANSFORMERS

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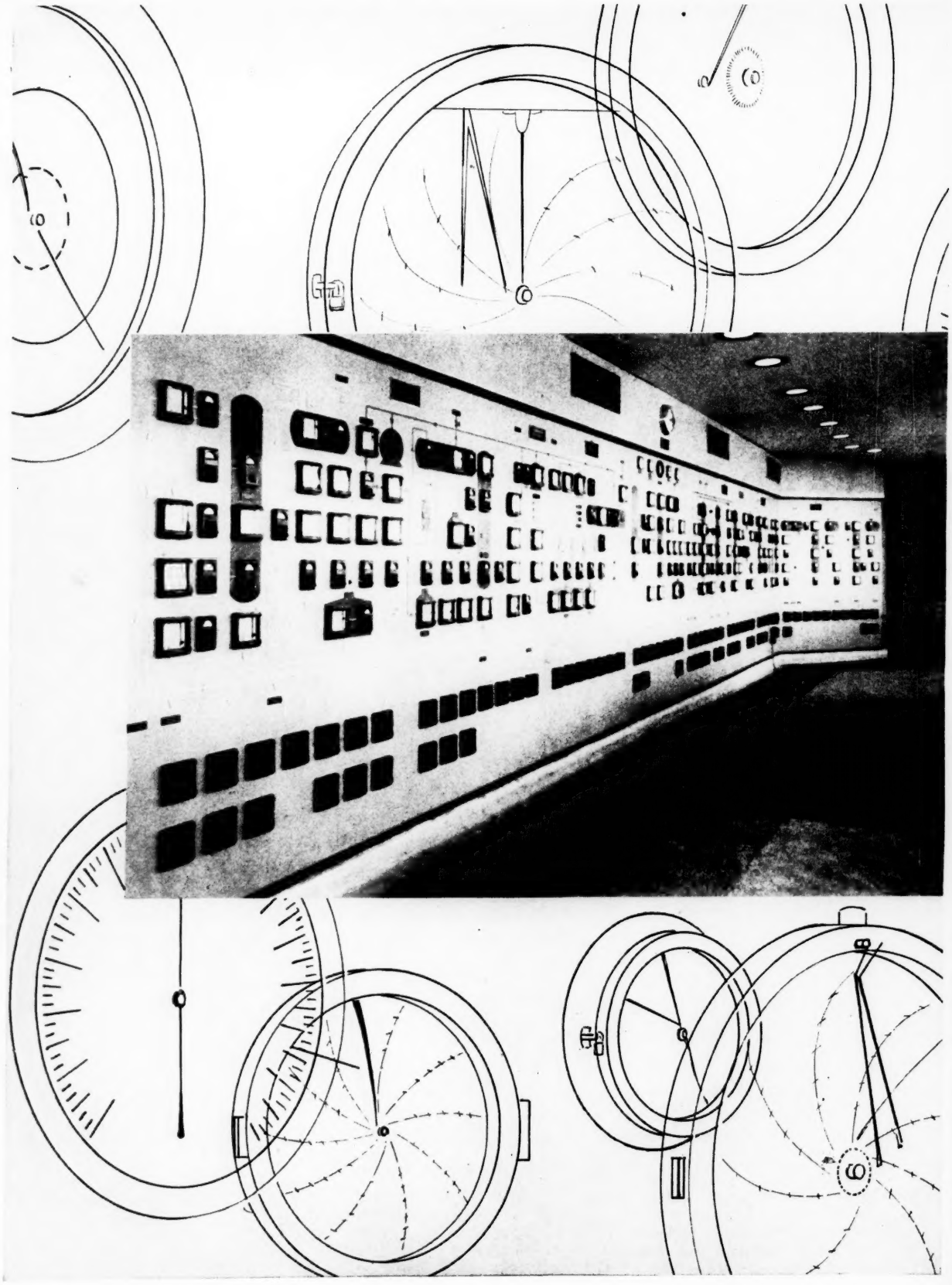
3615 Howard Street, Skokie, Illinois

For more information circle **36** on inquiry card.



M-2-58

For more information circle **37** on inquiry card.

AMERICAN-MICROSEN

FLEXIBILITY

anticipates ever-changing needs in process control

Some day your plant processes will include data handling or computing systems. Your processes will be changed to boost efficiency or to make new products for tomorrow's markets. You will use product stream analyzers.

Is your instrument system adaptable to keep pace with changes experience dictates in operating new processes?

The American-Microsen Electronic Process Control System is flexible. It is designed to solve ever-changing problems of process control. The DC signal used throughout is compatible with data handling systems. Changes in control arrangements are easy to make. Simply rewire instruments already on the job and plug in new components as needed. Standard instruments can be used for cascading, ratioing, programming, etc.

Flexibility is but one American-Microsen System advantage. Installation and operation are more economical. Accuracy is higher and control is closer whatever the distance between process and control room.

Try out the American-Microsen Process Control System. Write for information and ask one of our sales engineers to call. He will gladly explain how you can use the system profitably.

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Precision-built and self-contained, this portable instrument brings laboratory standards to the line or field installation. Available in a wide variety of scale ranges, full assortment of jets and fittings. You'll want all the facts (no safety department should be without a Velometer). Get Bulletin 2448-G. Attach this ad to your letterhead and mail to: Illinois Testing Laboratories, Inc., Room 518, 420 No. LaSalle St., Chicago 10, Illinois.

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For more information circle **38** on inquiry card.

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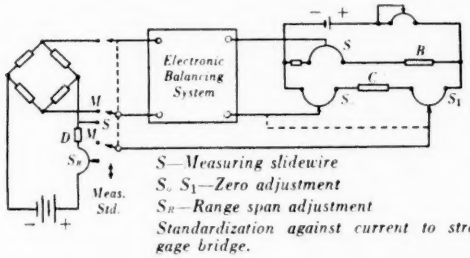
For more information circle **39** on inquiry card.

BRIEFS—CONTINUED

Speedomax Instrumentation

Physical quantities, such as temperature, position, level, stress, strain, speed, and light intensity—and chemical concentrations such as pH, electrolytic conductivity, and various gases—can be measured precisely through the use of primary detectors producing a change of voltage, current, or resistance which can be measured by Speedomax recorders . . .

The Speedomax balancing system is a precise electronic servo-mechanism, designed to operate a slidewire for balancing a null-type measuring circuit . . . Voltage across a slidewire is standardized to a known value, normally against a standard cell. A fraction of slidewire voltage,



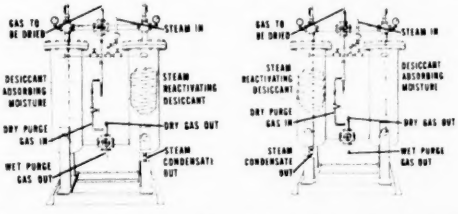
S—Measuring slidewire
S, S_1—Zero adjustment
S_R—Range span adjustment
Standardization against current to strain gage bridge.

proportionate to the position of the slidewire contact, opposes the voltage from the unknown source. When there is a difference between the impressed unknown voltage and the slidewire voltage, a current flows. This unbalance current is "chopped" by the converter to produce a 60 cycle current at the amplifier input terminals. The amount of 60 cycle current is proportional to the amount of unbalance; the phase changes 180 degrees with change of direction of unbalance. The amplified unbalance current is delivered to one winding of a two-phase servo-motor, which, in turn, moves the slidewire contact toward balance.—(*From new 48-page Technical Publ. ND46, Leeds & Northrup, 4907 Stenton Ave., Phila. 44, Pa.*)

For this literature circle **210** on inquiry card.

Dehydrators

Selas Dehydrators are designed and built to meet specific needs for effective and economical removal of moisture from most gases. Moisture removal and discharge from the system is continuous, with no flow inter-



ruption or interference. Gas inlet pressures may range from a few pounds gage to 150 psig for standard design with up to 3500 or more psig for special application. Outlet dewpoint (moisture level) is maintained safely below the specified level, which can run to −100°F . . . Reactivation heating can be performed with steam or electricity—depending usually on available utilities—although electric heating is generally preferred where extremely low dewpoint conditions are necessary . . . Operation of Selas Dehydrators can be either fully-automatic . . . semi-automatic . . . or manual . . . (*From new 4-page Bulletin SC-1013, Selas Corp. of America, Dresher, Penna.*)

For this literature circle **211** on inquiry card.

Circle **40** on inquiry card ⟶

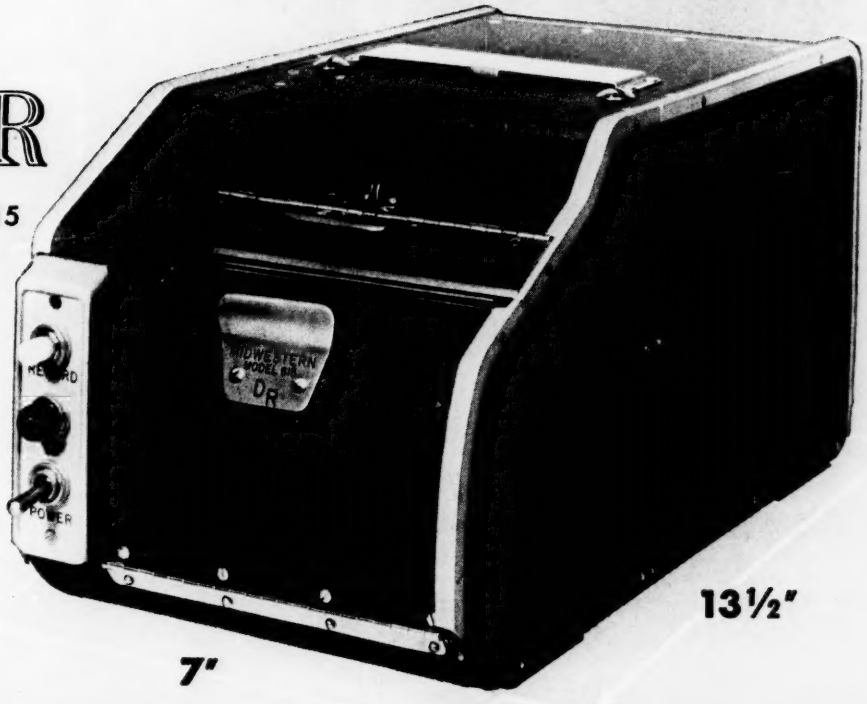
Theater 3000, I. R. E. Show, New York, March 24

NOW — A 14 CHANNEL DIRECT RECORDING

OSCILLOGRAPH

D/R

MODEL 615



Direct Readout
— DRY —
No Chemical Processing!

The 615 D/R is a small, compact and economical version of Midwestern's large 602 D/R and retains many of its outstanding features.

In applications where 14 channels are sufficient, the 615 D/R is welcomed by test engineers and laboratory researchers who prefer INCREASED ACCURACY + TIME SAVED.

Swift readout of completed records as they flow from this advanced instrument secures its position as a *top priority preference* in the field of oscillographic recording.

Standard Midwestern Galvanometers are used.

If you have a problem involving data recording under normal or extreme conditions — one of the many specialized models of Midwestern Instrument's oscillographs will be your solution — Call, wire or write Midwestern Instruments, Tulsa.

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INSTRUMENTS

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Ad No. 707

For more information circle **41** on inquiry card.

Measure any temperature from −200° F. to +600° F. with one instrument

Thermotest is the all-purpose testing instrument for precise measurement of temperatures from −200° F. to +600° F., and emf's up to 20.1 millivolts. It's the only portable potentiometer with interchangeable direct reading scales *and* automatic compensation. Measurements are read directly from the scale without charts, graphs or conversion tables. Scales interchangeable in seconds for use with three types of thermocouples. Mercury battery power supply. Leatherette covered case. Dimensions: 12¼" x 9" x 8½". Weight: 14 lbs. Write for free bulletin.

TECHNIQUE

TECHNIQUE ASSOCIATES, INC.
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INDIANAPOLIS 6, IND.

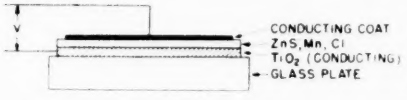
For more information circle **42** on inquiry card.

BRIEFS—CONTINUED

Light Amplification

Layers of the phosphor ZnS : Mn produced by the vapor raction method may be made to exhibit electroluminescence in alternating electric fields. If the glass upon which the deposition is to be made has an initial transparent coating of TiO_2, this coating becomes electrically conducting as the zinc sulfide forms on it. Thus an electroluminescent cell can be made by evaporating or painting an electrode on the surface of the zinc sulfide. A cross section of such a cell is shown.

It was while experimenting with a cell of this type, in which the phosphor layer consisted of ZnS : Mn, Cl,



that D. A. Cusano of this laboratory first observed the enhancement of luminescence by an applied d-c field, and in fact, demonstrated the amplification of incident radiation by such a field.

If in the process of making a manganese activated ZnS coating by the vapor reaction process, $ZnCl_2$ is used along with zinc, the Mn and Cl become coactivators, with the result that the screen responds to near ultraviolet as well as cathode rays. With a cell then, made as shown, when ultraviolet (e.g. 3650 A) is incident through the glass and the TiO_2 film, a yellow orange photoluminescence results. If now a d-c field is turned on (50 to 100 v for a film 10 u thick, TiO_2 positive), the brightness is greatly increased.—(*From 8-page brochure Res. Lab. Reprint* 2561, *General Electric Research Laboratory, Schenectady, N. Y.*)

For this literature circle **212** on inquiry card.

Bourdon Tubes for P-V-T

Since Bourdon's first hammer-hardened copper tubes, millions have been made of every kind of material that can be formed into tubes, including blown glass. Bourdon tubes are now made mostly of high carbon steels, alloy steels, copper alloys and of other metals that can be improved by heat treatment.

The accuracy of gauges developed by Otto Heise during years of design and manufacture of Bourdon tube gauges has notably advanced the art of measuring high fluid pressures. It was 1930 that he produced the Heise-Bourdon tube that made it possible, for the first time, to equip testing a machine with Bourdon gauges for measuring the forces applied on material under test with extreme accuracy . . . The A. H. Emery Co., manufacturers of Testing Machines, were the first to use Heise Bourdon gauges, and have continued to apply them on all their testing machines.

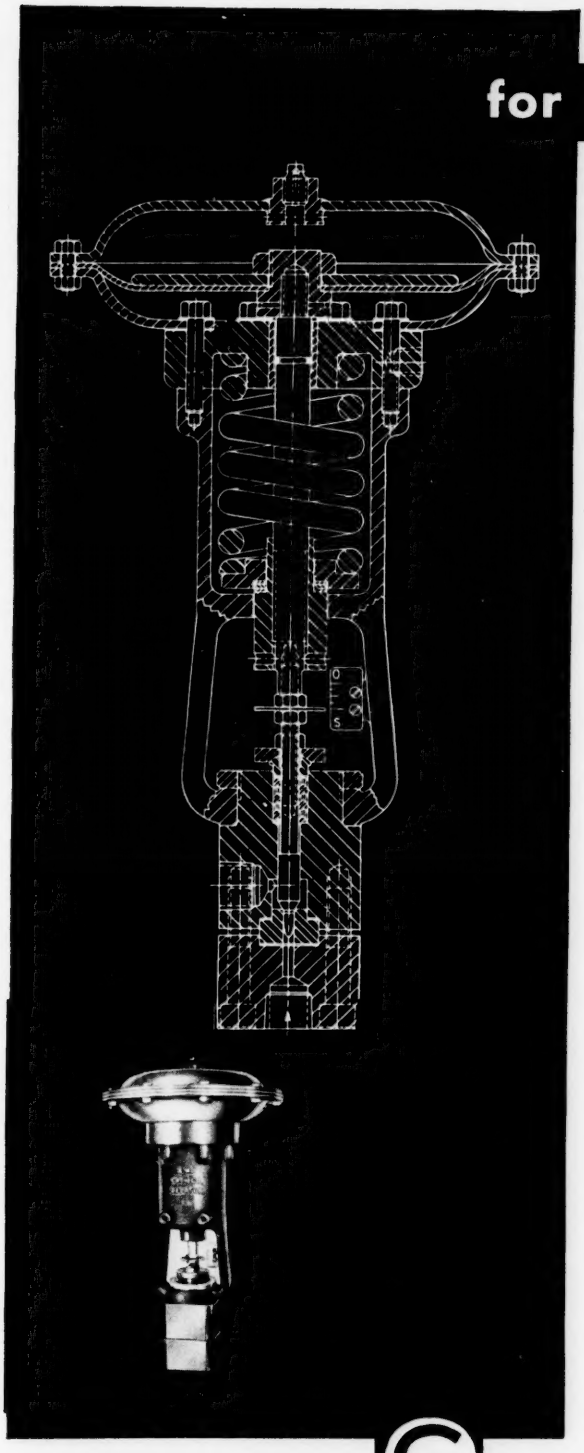
Specially designed Heise gauges have been used successfully for the determination of the Pressure-Volume-Temperature (P-V-T), relationships of gases for many years. The critical nature of this work makes it an extreme test of gauge quality, involving pressures at nearly maximum calibration maintained for long periods, and requiring tightness against mercury.

Heise gauges satisfy the requirements of this application, indicating the slightest pressure variations and keeping hysteresis within one half of one per cent of full scale.

Tubes of small cross section used in gauges for P-V-T determination maintain a low fiber stress and develop little force. A ball bearing movement, designed for these gauges, makes possible extremely sensitive indication. (*From new 16-page bulletin "Heise Gauges," Heise Bourdon Tube Co., Inc., Brook Rd., Newton, Conn.*)

For this literature circle **213** on inquiry card.

for 10,000 psi service



CASH STANDARD TYPE 505

diaphragm operated high pressure control valve

Specially designed to handle gases and liquids in high pressure drop, on-off or throttling service, with dead-end shutoff.

pressure and temperature rating:

10,000 psi at —40 to 400°F.

action:

Direct or reverse.

packing:

Teflon V-ring, bolted gland.

spring:

Enclosed type with thrust bearing on adjusting screw. 3-15 and 6-30 psi ranges standard.

body:

Forged stainless steel, split body, with hardened stainless steel trim.

connections:

½" and ¾" NPT. Connections for high pressure tubing also available.

What is Your Pressure Control Problem?

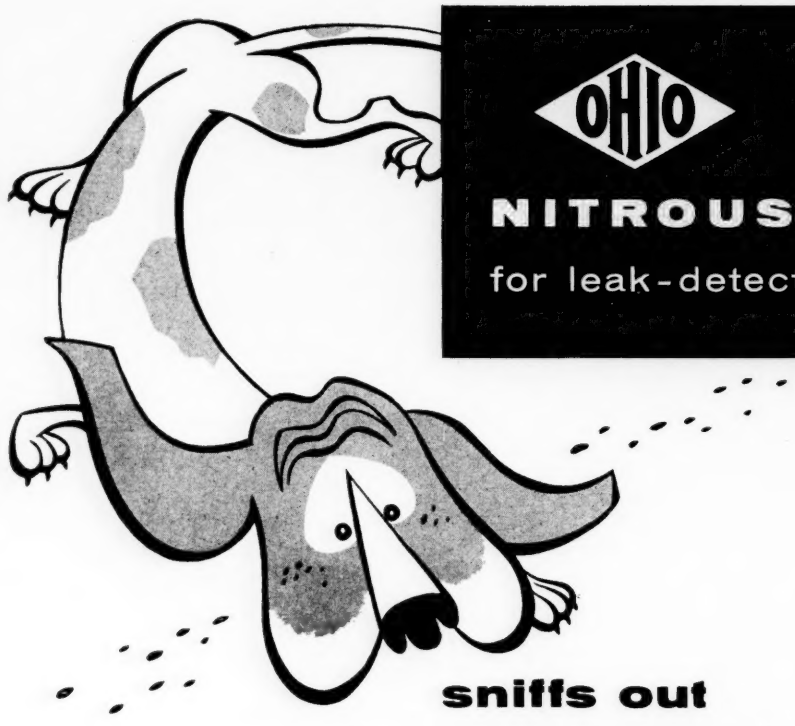
Consult the Cash Standard control specialist in your area or write for complete information. Dept. O.

CASH CS STANDARD

A. W. Cash Co. and Its Subsidiary, Cash Standard Stacon Corp.
P. O. Box 551, Decatur, Ill.

Pressure, Hydraulic, Temperature, Process and Combustion Controls

For more information circle **43** on inquiry card.



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NITROUS OXIDE

for leak-detection devices

sniffs out microscopic leaks!

OHIO NITROUS OXIDE

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- Noncorrosive
- Nonflammable
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FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection on pressure vessels, piping systems, auto suspension systems, or in any other problem concerning leak detection. For further written information, please write Dept. IA-1 requesting the following bulletins:

1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests.

1B Gas Service Equipment for Nitrous Oxide Supply.

Infrared determination of nitrous oxide gives you a highly sensitive, clean and flexible method of leak detection when used for test pieces of many sizes, and for large and small quantities. Just a few parts of nitrous oxide can be detected in a million parts of air.

Audible or visual warning devices may be used. This method is insensitive to usual atmosphere components, such as moisture, carbon dioxide and hydrocarbons.

Nitrous oxide offers you top efficiency, and does so at an exceptionally low cost when compared to other gaseous agents.

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Madison 10, Wisconsin
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Dep't. IA-3

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City ..... Zone ..... State .....

Your Name ..... Title .....

At the frontiers of progress you'll find **An Air Reduction Product**... **Ohio**: Medical Gases and hospital equipment • **Airco**: Industrial gases, welding and cutting equipment, and acetylenic chemicals • **Pureco**: Carbon dioxide, liquid solid ("Dry Ice") • **National Carbide**: Pipeline acetylene and calcium carbide • **Colton Chemical**: Polyvinyl acetates, alcohols and other resins

For more information circle **44** on inquiry card.

Circle **45** on inquiry card. →

These could be the

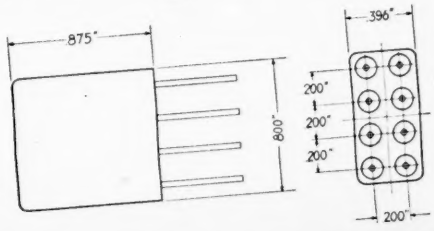
MOST IMPORTANT RELAY "SPECS" *you ever read!*

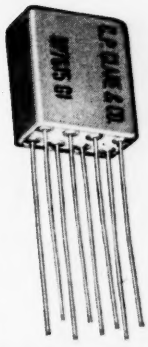
• Here is a relay admirably geared to the needs of today's advanced circuit designers. Hermetically sealed—no bigger than a postage stamp —stalwart to withstand extremes of temperature, heavy shock and severe vibration—yet fast and more than moderately sensitive.

CLARE *Type F* RELAY

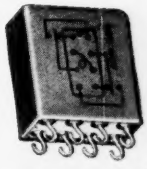
SPECIFICATIONS

Ambient Temperature	—65° C to +125° C.
Shock	50 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ⅛-inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltages or currents.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also for low-level applications.
Contact Resistance	0.050 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018; MIL-R-5757C, except as to contact overload.

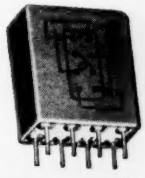




Designers of printed circuit layouts will note terminal arrangement is nicely suited to 1/10 inch grid spacing.



Contacts, rated at 3 amperes, are proven also for low-energy level circuit applications.



All popular mounting arrangements are available.

For complete information send for Bulletin 124. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: Clarelay

CLARE RELAYS

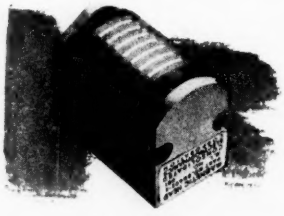
FIRST in the industrial field

only

DataTape

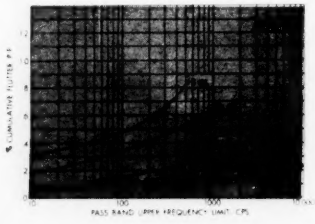
offers

all-metal-surface magnetic heads

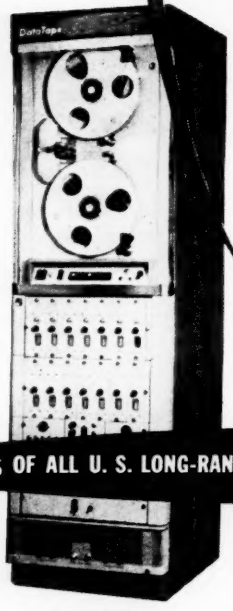


No more drop-outs or loss of high-frequency response because of oxide build-up on heads. All-metal-surface... rather than conventional metal-plastic combinations... promotes a self-cleaning action and minimizes head wear.

lower flutter even at low tape speeds

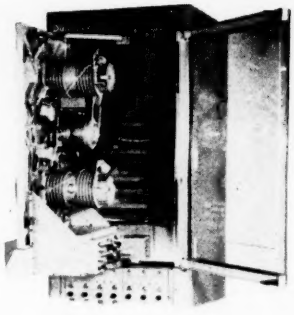


Cumulative flutter at 1⅞ and 3¾ ips is approximately one-half that found in other tape equipment. CEC is first to achieve the low-speed flutter characteristics shown at left. Chart shows flutter recorded at 30 ips and played back at speeds indicated.



complete front access

The 5-752 is the only recorder/reproducer offering complete front access to all incoming and outgoing signal, control, and power interconnections. Access to internal amplifier circuits is through standard connectors on front of unit. All electronics are mounted on drawer slides.



CEC *magnetic tape recorder/reproducer system*

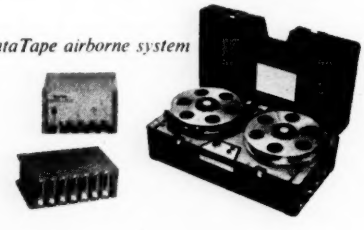
90% OF ALL U. S. LONG-RANGE MISSILE TEST FLIGHTS ARE RECORDED ON CEC DATATAPE

Simplify your data problems. Get instantaneous playback up to 14 tape tracks with CEC's 5-752 Recorder/Reproducer System with simultaneous recording or reproducing of separate signals on one-inch tape. Seven different types of plug-in amplifiers record and reproduce in Analog, PDM, or FM modes. Contact your nearby CEC field office, or write for Bulletin CEC 1576-X16.

TYPICAL APPLICATIONS – Telemetering from Missiles and Aircraft, including FM sub-carrier telemetering. Wind-Tunnel Testing. Jet and Rocket Engine Testing. Studies of Shock and Vibration. Mobile and stationary Structural Testing: ships, trains, etc. Static and Dynamic Testing: airframes and components. Sound measurements: all types of analyses, including, sonar, medical research.

Continuous loop transport

DataTape airborne system



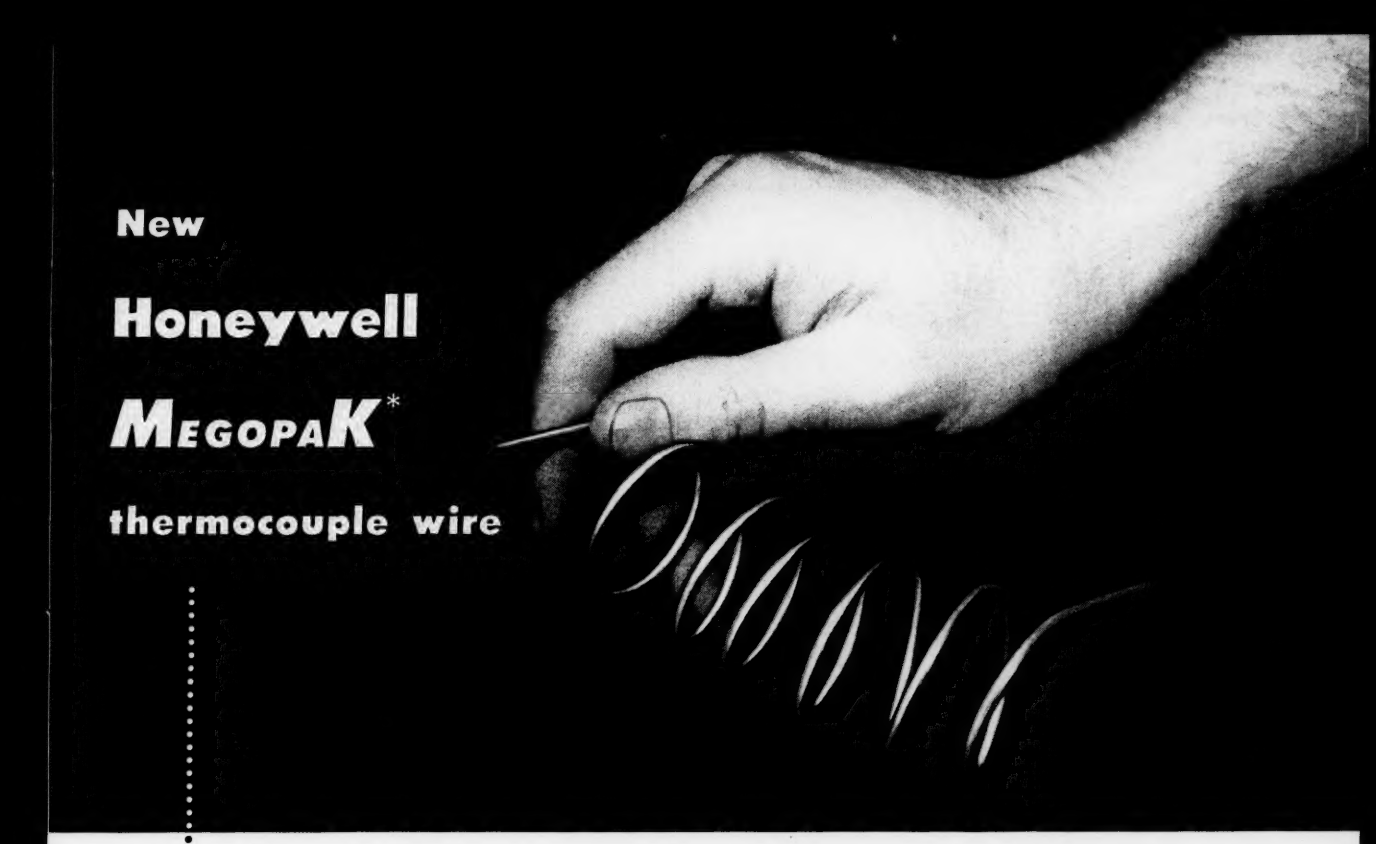
DataTape Division

Consolidated Electrodynamics CEC

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **46** on inquiry card.



New

Honeywell MEGOPAK* thermocouple wire

Originally designed for atomic energy applications

. . . now available through your **HSM** HONEYWELL SUPPLIES MAN

MEGOPAK wire is the latest development in small-diameter thermocouples, with emphasis on durability and high accuracy.

Here are some of its features:

- Allows use of small-diameter thermocouples without protecting tubes at very high temperatures.
- Available in either 1/16 inch or 1/8 inch diameter, in lengths from 6 inches to 25 feet in 6 inch increments.
- Easily bendable around twice its own diameter—yet will remain rigid in lengths up to 12 inches.
- Has protective sheathing of stainless steel or *Inconel***—easily stripped for making "on-the-job" thermocouples.
- Available in either *Chromel Alumel**** or iron-constantan.
- Ruggedly built to withstand severe mechanical abuse.

MEGOPAK wire is one of the many special pyrometer supplies available with personalized service from your HSM (Honeywell Supplies Man). For complete details, call the HSM at your nearby Honeywell branch . . . as near as your phone. Or write for Specification S001-4.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

*Trademark Minneapolis-Honeywell Regulator Co.
**Trademark International Nickel Co.
***Trademark Hoskins Manufacturing Co.

H HONEYWELL

MINNEAPOLIS **Honeywell**
BROWN INSTRUMENTS
First in Controls

You can't beat all-plastic Dekoron Poly-Cor for chemical resistance or for ease of installation. And now, the *new* Dekoron Instrument Tubing Harness adds yet another revolutionary feature—*fire resistance.*

For example, in the direct flame of a cutting torch, it lasted longer than any other multiple-tube harness. Use it in areas where flash fires are anticipated. And *new* Dekoron Instrument Tubing Harness is rugged, too. You can bury it and forget it.

You get all the advantages—chemical, impact and fire resistance—wrapped up in a single bundle with *new* Dekoron Instrument Tubing Harness. Remember, you can burn it . . . you can bang it . . . you can bury it. And you can *buy it now.*

AA-4622

Dekoron® products

QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY
DEKORON PRODUCTS DIVISION
MANTUA, OHIO

For more information circle 47 on inquiry card.

BIOGRAPHIES

Probably the greatest single amount of plant instrumentation specified by one activity is attributable to plant constructors, such as the Lummus Company. Ward F. O'Connor is Chief Mechanical Engineer for The Lummus Company, and an instrument specialist. His is one of the most important positions in the field of instrumentation, and we are proud, this month, to acknowledge his many contributions to our field.

WARD F. O'CONNOR

Instrument engineers always have been recruited from all the branches of science and engineering, and Ward O'Connor is an electrical engineer. He received his B. S. degree in EE from the University of Notre Dame in 1931.

From graduation until 1939, Ward served as Field Engineer for Ford, Bacon & Davis, Inc., and in the sales Department and Refinery of Standard Oil Company of New Jersey.

His interest in instrumentation began with his duties with Standard, where he performed maintenance on plant instruments and process controllers at the Bayonne Plant of Standard Oil Company of New Jersey. It was here that the fascination of process controllers led him to deeper study of and greater concentration on the needs, availability, and application of process instrumentation. As with all process instrumentation, he found it necessary to become expert not only with the instrumentation but with the processes of his company.

In 1939 Ward joined the Lummus Company, where he has been responsible for instrument engineering, including plant operations. For seven years he assumed complete responsibility for methods and types of control for all plants built by the Lummus Company, including oil refineries, chemical plants, paper mills, and power reactors. This included, of necessity, all types of process instrumentation. His responsibility included installation, startup, and operation of all the mechanical and control equipments in these plants.

As Manager of the Mechanical Engineering Department he supervised

of Significance

Ward F. O'Connor

groups of engineers specializing in mechanical equipment such as exchangers, filters, pumps, compressors, jets, instruments, and controllers.

Instrument engineers commonly face new problems, requiring new equipments and techniques. Ward has had many such problems, some of which led to basic force-balance type controllers now in common use with miniature instruments. He has also engineered and designed complete electronic process control systems, including computation and data reduction.

Ward holds many patents in industrial, chemical, and petroleum refining processes. Some are associated with catalyst handling, solids measurement and control, hydraulic decoking, and emulsifying. In instrumentation, his patents cover miniature force-balance instruments, graphic panels, and special control problems.

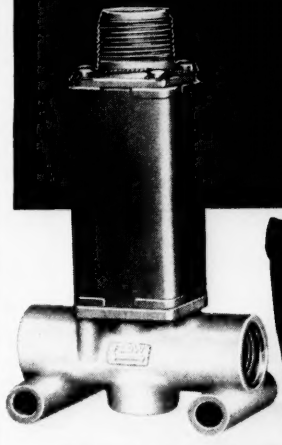
Ward is also an author and lecturer. He has authored and co-authored many technical articles, and has lectured before many technical societies and university groups—Brooklyn Polytechnical Institute, Princeton University, University of Pennsylvania, and Houston University. At the Fourth International Automation Exposition to be held on June 9-13, 1958, Ward will be Chairman of the Technical Session on Data Acquisition and Reduction.

Ward has been married for 24 years and has five children. His hobbies include home building and design, and he tells us that he has been a reader of I&A for twelve years.

*The only valve that improves with use!

VALCOR's patented "Floating Seal" solenoid valve actually improves with use, due to its unique self-lapping action. The "heart" of this valve is a precise, optically flat, carbon-graphite disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally flat, stainless steel seat, sealing perfectly.

Are the valves you use as good as . . .



Valcor's?

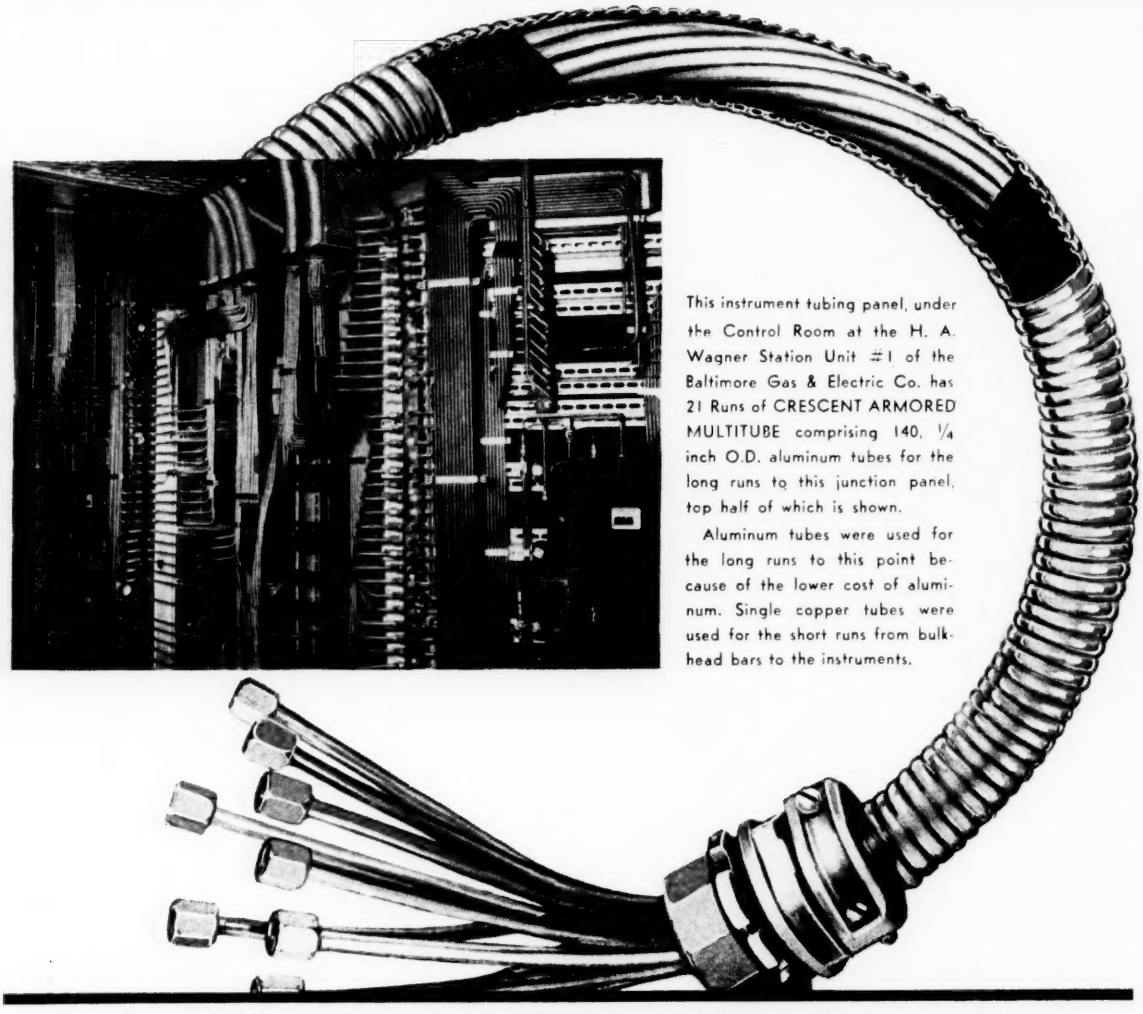
The imaginative engineering which created the "Floating Seal" has been responsible for the use of over a half million VALCOR solenoid valves in Military Aircraft and Guided Missiles. Hundreds of thousands more are in constant use throughout industry. Tell us your valve problems . . . let our engineering staff offer its recommendations. Write today for Catalog 105 and other valve information.

VALCOR ENGINEERING CORP.
5366 CARNEGIE AVENUE, KENILWORTH, NEW JERSEY

VALCOR
SOLENOID VALVES

For more information circle **48** on inquiry card.

CRESCENT ARMORED MULTITUBE*



This instrument tubing panel, under the Control Room at the H. A. Wagner Station Unit #1 of the Baltimore Gas & Electric Co. has 21 Runs of CRESCENT ARMORED MULTITUBE comprising 140, 1/4 inch O.D. aluminum tubes for the long runs to this junction panel, top half of which is shown.

Aluminum tubes were used for the long runs to this point because of the lower cost of aluminum. Single copper tubes were used for the short runs from bulkhead bars to the instruments.

for dependable performance of instrumentation and control tubing

CRESCENT ARMORED MULTITUBE® is a group of tubes spirally cabled together. One tube in each layer is a bright blue color, which makes identification of any tube at both ends an easy matter.

Users report savings in installed cost of from two to five times the cost of CRESCENT ARMORED MULTITUBE as compared with the old method of using single tubes. Using the MULTITUBE system will result in fewer connections and fittings, lower cost for supports or racks, ease of mounting and less space.

The spiral cabling of the tubes prevents distortion when the entire assembly is bent on a short radius. The tubing assembly is protected by a flexible, interlocked galvanized steel armor, or by a tough corrosion-resistant thermoplastic sheath or both.

Furnished in from 2 to 37 Tubes of copper, aluminum, steel, polyethylene up to 1000 feet. Also special construction for underground runs. This product is licensed under U.S. Patent 2,578,280.

Send for Bulletin 356-A giving complete information and engineering data

CRESCENT INSULATED WIRE & CABLE CO.

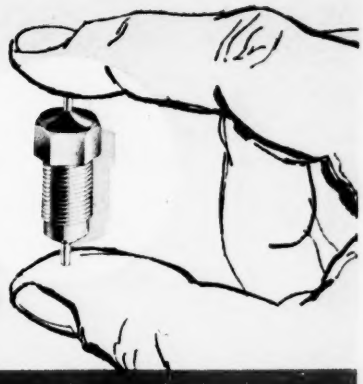
TRENTON, NEW JERSEY

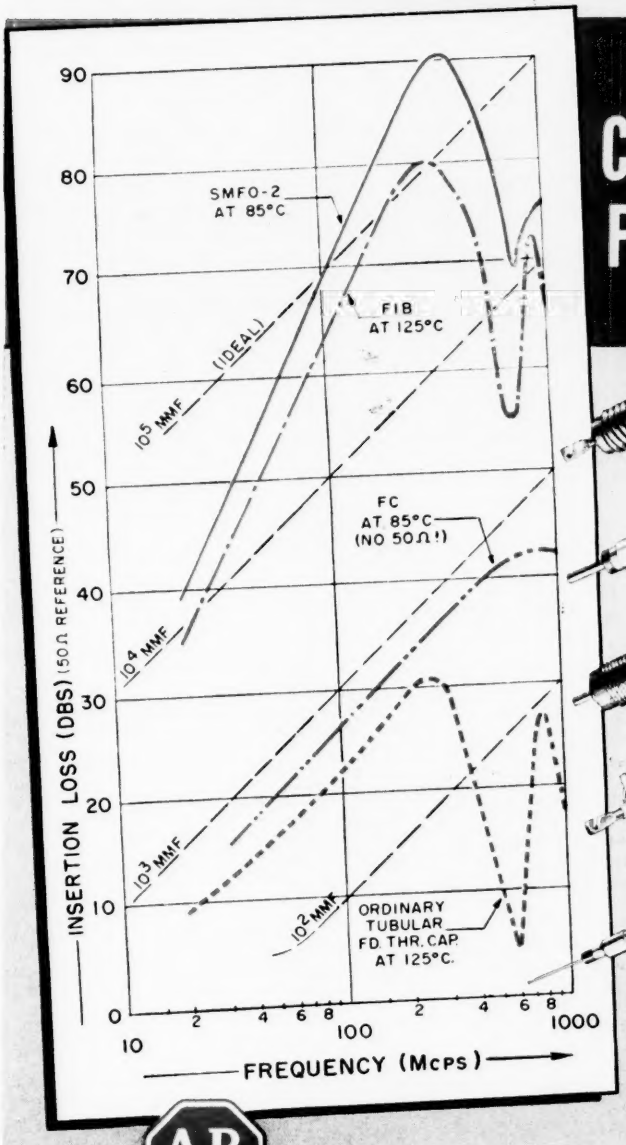
* Reg. Trade Mark

For more information circle **49** on inquiry card.

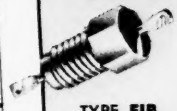
a new idea

in the elimination of high frequency radiation





ALLEN-BRADLEY
CASCADED CERAMIC FEED-THRU FILTERS
(PATENT PENDING)

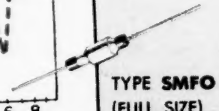


TYPE **FIB**

TYPE **FIS**

TYPE **FCD**

TYPE **FC**



TYPE **SMFO** (FULL SIZE)

NOW . . . out of the Allen-Bradley research laboratories comes a completely new and far more effective line of high frequency filter elements . . . especially designed to eliminate radiation from low power circuits operating in the frequency range from 50 mcs to 5000 mcs.

Employing an entirely different concept, these new filter elements have a phenomenal filtering efficiency . . . that actually *increases* tremendously with frequency, as illustrated in the graph at left.

These filter elements display none of the detrimental internal resonance characteristics of standard tubular capacitors . . . and cascading elements permit an increase in effective capacity far beyond that practical even with discoidal design.

Filters are available in voltage ratings up to 500 v, DC at temperatures up to 125°C. Max. RF current is 0.25 amp, and max. DC or low frequency current is 5 amp.

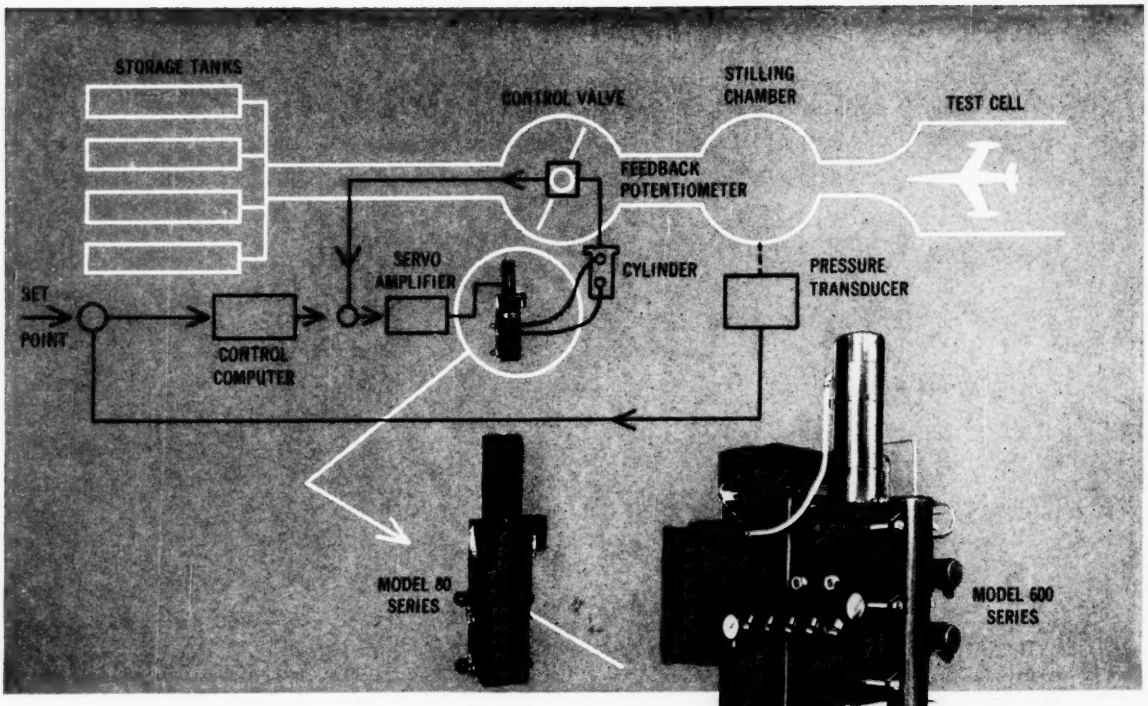
Technical information available upon request.

A-B QUALITY

ALLEN-BRADLEY
ELECTRONIC COMPONENTS
QUALITY

Allen-Bradley Co., 1315 S. First St., Milwaukee 4, Wis. • In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

For more information circle **50** on inquiry card.



ELECTRO-HYDRAULIC PILOT VALVES

CAPACITIES TO 600 GPM

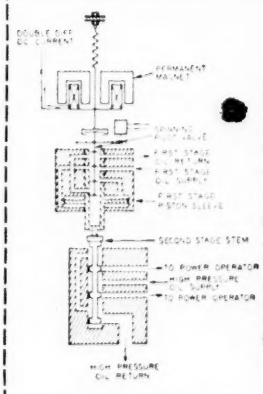
Frequency Response - to 10 cps - Accuracy - better than 0.1% - Hysteresis - less than 0.05%

Hagan PowrAmp Electro-Hydraulic Pilot Valves are dc actuated, permanent magnet motor driven, two stage servo valves used for the transfer and control of high pressure hydraulic fluid to power cylinders or motors driving dampers, valves, test models etc. As seen in the diagram at right, dc current inputs drive the first stage spinning pilot valve. This first stage hydraulic output drives the first stage piston-sleeve and the second stage high pressure stem.

Operating with supply pressures of up to 2000 psig and available in 18, 54, 80, 185, 369 and 600 gpm capacities at 2000 psi pressure drop, the Hagan Electro-Hydraulic Pilot Valve can control up to 300 usable hydraulic horsepower. Its permanent magnet motor and spinning pilot valve design provide virtually a frictionless and hysteresis-free valve as compared with the conventional iron core solenoid type of valve. The complete isolation of first and second stage valves allows the second stage to be applied in pneumatic service if desired.

This high power servo valve is a part of the Hagan "PowrAmp" line which also includes transducers for most key variables and electronic control computers. Available as separate components or as units of engineered systems, the complete line is described in Bulletin MSP-133, which will be sent on request.

For additional information on the Hagan Electro-Hydraulic Pilot Valve, write for Specification Sheet GH-300.



SPECIFICATIONS

Capacities—Up to 600 gpm at 2000 psi drop

Hysteresis—Less than .05% full valve stroke

Repeatability—Better than 0.1% full valve stroke

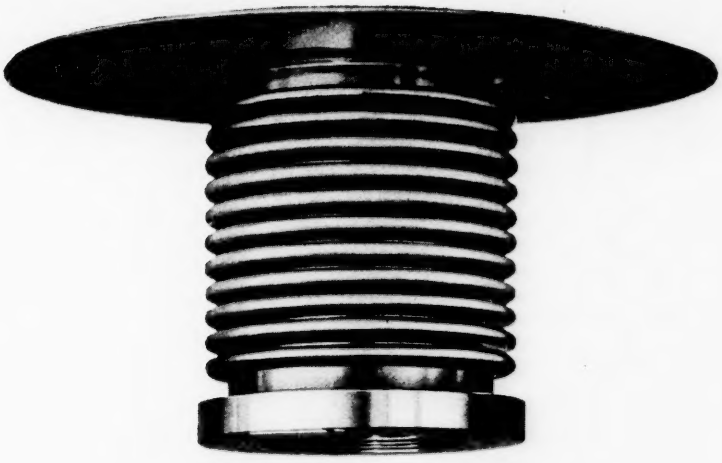
Closed Loop Frequency Response—1½ to 10 cps depending on model and load

Input—Double differential dc currents of ±50 ma. Resistance of each coil 500Ω. Maximum current, each coil, 100ma. Maximum voltage, 100 vdc.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

For more information circle **75** on inquiry card.

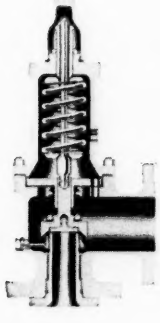


CORRUGATED SLEEVE

shields working parts

A durable, two-ply stainless steel Sealing Bellows in Consolidated Safety Relief Valves isolates contaminants, corrosion or viscous fluids from the working parts. The Bellows is balanced with the seating surface. Capacity is less affected by variable back pressure, so you can use smaller discharge piping and reduce the cost of pressure-relieving systems.

Full-rated relieving capacity is certain at all positions of the single blowdown adjusting ring because a fixed maximum secondary orifice provides full lift at 10% overpressure. Even with superimposed back pressure in the relieving system, valve action is consistently positive.



Protection of working parts is but one of many reasons why Bellows Type Consolidated Safety Relief Valves assure absolute protection for personnel and facilities. Write for details, including facts about the Standard valve that you can convert to the Bellows type in your own shop. Ask for Catalog 1900.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

TI-58

CONSOLIDATED SAFETY RELIEF VALVES

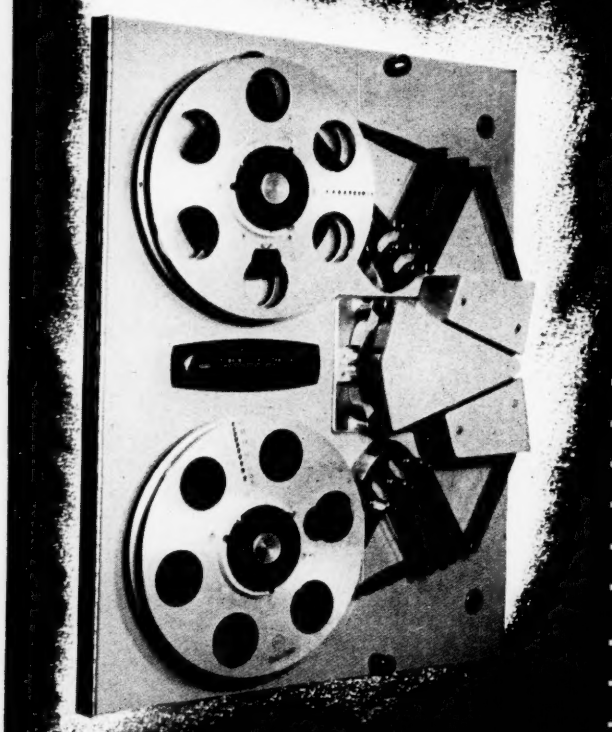
A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Tulsa, Oklahoma
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **52** on inquiry card.

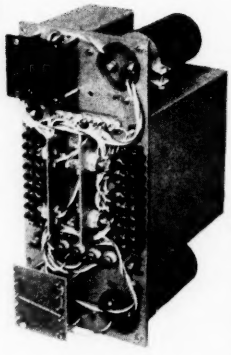
← Circle **51** on inquiry card.



CEC announces the new digital magnetic tape recorder/reproducer

- *all transistorized electronics*
- *modular construction**
- *starts and stops in less than 5 milliseconds*
- *high-speed servo response*
- *continuous-duty servo motors*
- *all-metal-surface magnetic heads*
  (½" SPACING BETWEEN READ AND WRITE HEADS)
- *uses ½" to 1¼" tape*
- *10½" reels with NARTB hubs*
- *designed for standard rack mounting*
- *size: 19" wide by 24½" high by 13" deep*

NOW AVAILABLE... Not merely a laboratory instrument, but a fully ruggedized, reliable digital recorder designed for a whole gamut of industrial applications where long periods of unattended operation with minimum maintenance and down-time are paramount. Standardized speeds, track-width and spacing, and start and stop distances assure complete compatibility with other digital tape transports and handlers. *Contact your nearby CEC field office for complete information,* or write for Bulletin CEC 1608-X4.



**Modularized components, such as Power Supply Unit at right, permit instant access and easy maintenance or replacement with minimum down-time.*

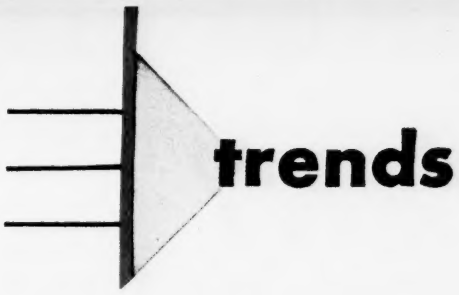
DataTape Division

CEC Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **53** on inquiry card.



BDSA report of Dept. of Commerce on Outlook of Major Industries for 1958 says that sales of Scientific and Industrial Instruments (used in research and development laboratories and by industry) for the first half of 1958 should run at the annual rate of $3 billion--the same as for 1957. For the last half, the annual rate should average about $3.25 billion. The 1957 figure was 20% over 1956.

Electronic market trends are analyzed by D.G. Mitchell of Sylvania Electric Products as follows (all figures in billions):

	1957	1958	1961	1966
Defense	$3.8	$4.2	$5.3	$6.4
Distribution	$2.7	$2.8	$3.5	$4.9
Broadcasting	$2.0	$2.2	$2.9	$4.1
Industrial & Commercial	$1.3	$1.3	$1.9	$2.9
Entertainment	$1.5	$1.6	$1.9	$2.4
Service	$1.1	$1.1	$1.3	$1.7

British Conference on Automation and Computation has been formed comprising groups from 23 British technical societies, and consisting of 3 Groups–(1) British Group for Engineering Applications of Automation, (2) British Group for Computation and Automatic control, and (3) British Group for Sociological and Economic aspects of Automation techniques.

U. S. equipments and component sales for both U. S. and foreign nuclear reactors in decade 1958-1968 are estimated at $4 billion, according to survey made by Atomic Industrial Forum.

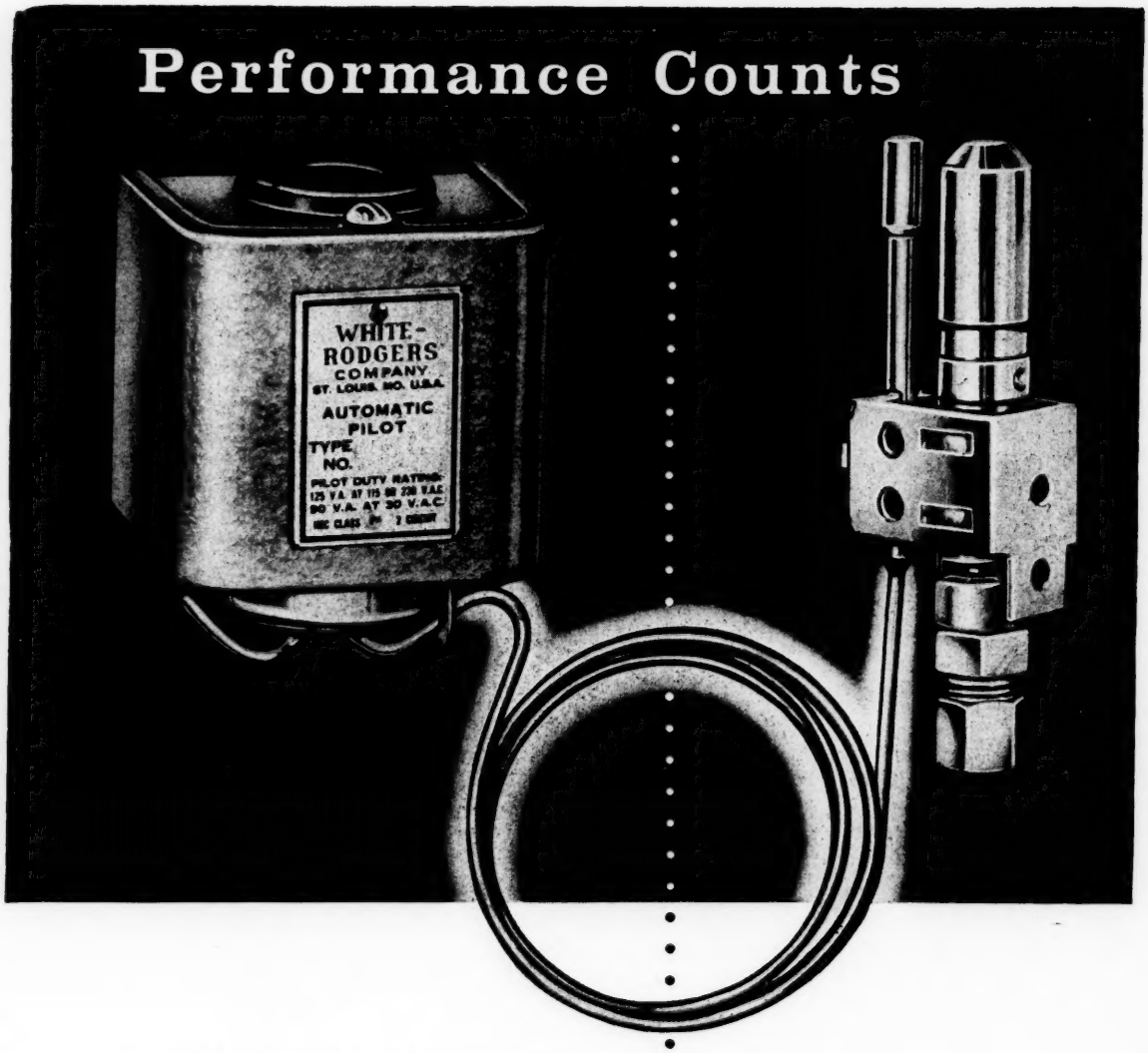
AEC spent $2 billion in fiscal 1957; $1.6 billion 1956; $1 billion in 1954; $0.4 billion in 1950. Total for 1957 included about $12 million for electronic equipment purchases. From 1950 to 1954, AEC and its contractors spent about 0.6% of total on instruments.

EAI reports that country's armed forces spend $20 million daily for maintenance of electronic equipment. This is $7.3 billion annually.

Industrial productivity which was gaining at a healthy 4% rate ten years ago, has slipped to less than 1% reports New York Herald Tribune.

Survey of sales of general-purpose digital computers by J. Diebold & Associates reports that 241 large-scale computers have been delivered, with 279 on order; 1,036 medium-scale have been delivered, with 1321 on order; 4720 small-scale have been delivered, with 1667 on order. Note: large-scale includes IBM 700 series; medium-scale includes IBM 650 class, Bendix G-15, etc. small-scale includes IBM 604 E-101, LGP-30, etc.

Performance Counts



White-Rodgers Co. selects BISHOP #347 CBTA **CAPILLARY TUBING** with an .078" OD and .031" ID for dependable performance in its automatic *Safety* pilots found in the majority of today's gas clothes dryers . . . another typical application of BISHOP *quality* tubing by today's instrument manufacturers.

For *accurate, dependable performance* of your instruments, specify BISHOP tubing.

Capillary, Mechanical, Hypodermic Seamless and welded and drawn Tubing (.008" to 1" OD – .003" to .083" Wall)

Nickel and Nickel Alloy Tubing (up to .625" O.D.)

Catalog on request.

STAINLESS STEEL PRODUCTS DIVISION

J. BISHOP & CO. Platinum Works

Malvern, Pennsylvania

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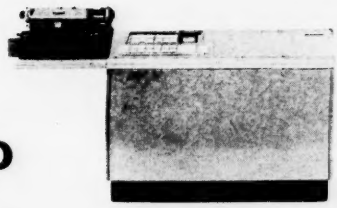
TODAY'S GREATEST VALUE IN ELECTRONIC COMPUTERS!

ROYAL PRECISION LGP-30



Compare it, feature by feature, with the other computers in its class

Feature	Computer A	Computer B	Computer C	Computer D	LGP-30	
Memory Size	220 words for data only	2160 words	1000 or 2000 words	84 words for data only	**4096 words for data & program (either or both)**	**LARGEST CAPACITY IN ITS CLASS**
Max. Speed Add Multiply	 20/sec. 4 sec.	 Comparable to LGP-30	 Comparable to LGP-30	 3/sec. 1/sec.	 **Over 440/sec.** **Over 50/sec.**	**SPEED EQUAL TO MANY ROOM-SIZED COMPUTERS**
Size	17 sq. ft.	6.5 sq. ft. plus table for typewriter.	45 sq. ft.	9.2 sq. ft. plus table for typewriter & control unit.	**11 sq. ft.**	**COMPACT, DESK-SIZED, COMPLETELY MOBILE**
Input-Output	Keyboard only — tape at extra cost.	Independent tape preparation at extra cost.	Extra cost peripheral equipment required.	Tape and typewriter for numerical input-output only. Independent tape preparation at extra cost.	**Tape typewriter for alpha-numeric input-output standard equipment.**	**DELIVERED COMPLETE. NO ADDITIONAL EQUIPMENT NEEDED TO PREPARE DATA, PROGRAM OR REPORTS**
No. of tubes	165	450	2,000	248	**113**	**FEWER COMPONENTS MEAN LESS MAINTENANCE, FEWER CHECKOUTS**
Voltage	220 V	110 V	220 V	110 V	**110V**	**PLUGS INTO ANY REGULAR WALL OUTLET**
Power	2.5 KW	3.0 KW	17.7 KW	1.65 KW	**1.5 KW**	**NO SPECIAL WIRING OR AIR-CONDITIONING REQUIRED**
Ease of programming & operation	Not alpha-numeric. No internal program storage.	Alpha-numeric at extra cost. 8 part instruction. Requires computer specialist.	Alpha-numeric at extra cost. Requires computer specialist.	Not alpha-numeric. No internal program storage.	**Alpha-numeric. Complete internal program storage. Standard typewriter keyboard. Simplest command structure of all.**	**EASY TO PROGRAM AND OPERATE.**
Cost Sale Rental	 $38,000 $1000/mo.	 $49,500 $1485/mo.	 $205,900 $3750/mo. up	 $55,000 $1150/mo.	 **$49,500** **$1100/mo.**	**LOWEST COST EVER FOR A COMPLETE GENERAL PURPOSE COMPUTER**

Nation-wide sales and service. Trained staff of applications analysts. Library of subroutines available, plus programs for wide variety of applications.

For further information and specifications on Royal Precision LGP-30, call your nearby Royal McBee office, or write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.

ROYAL McBEE

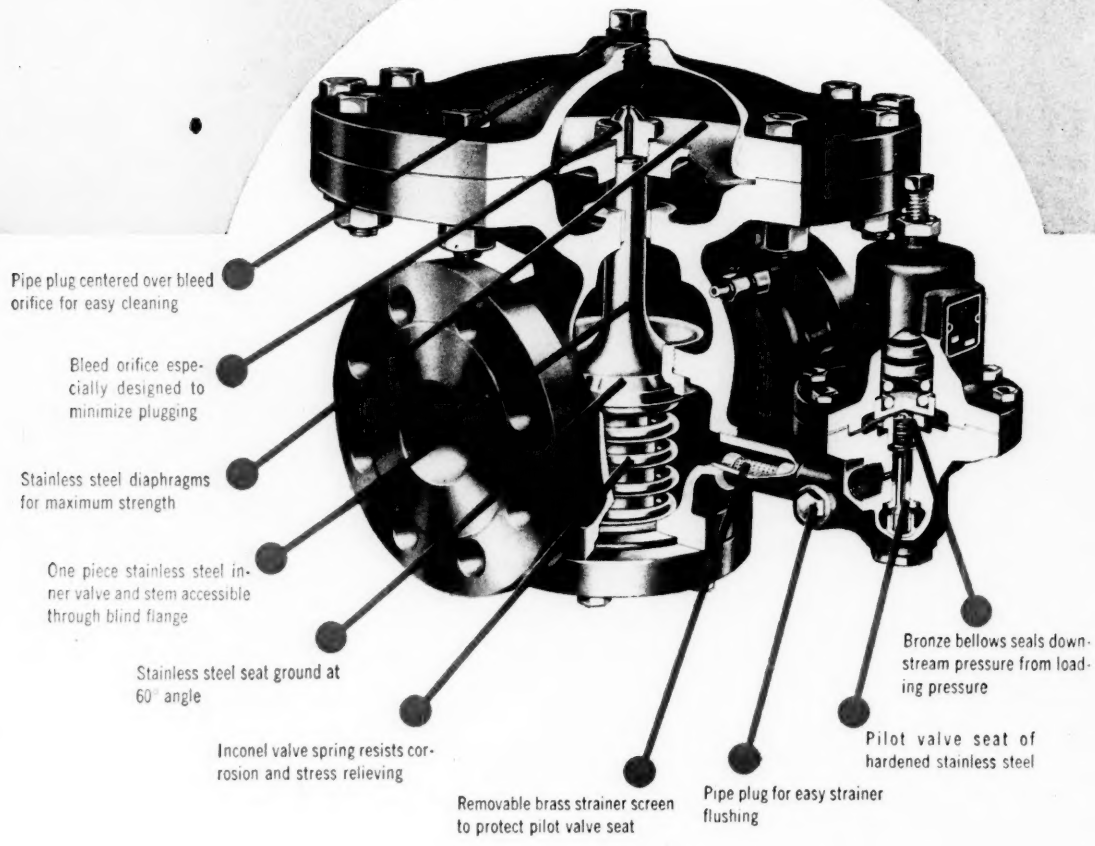
WORLD'S LARGEST MANUFACTURER OF TYPEWRITERS AND MAKERS OF DATA PROCESSING EQUIPMENT

For more information circle **55** on inquiry card.

THE FISHER® 92B

IMPROVED

TO MINIMIZE PROBLEMS INHERENT IN STEAM SERVICE


Pipe plug centered over bleed orifice for easy cleaning
Bleed orifice especially designed to minimize plugging
Stainless steel diaphragms for maximum strength
One piece stainless steel inner valve and stem accessible through blind flange
Stainless steel seat ground at 60° angle
Inconel valve spring resists corrosion and stress relieving
Removable brass strainer screen to protect pilot valve seat
Pipe plug for easy strainer flushing
Pilot valve seat of hardened stainless steel
Bronze bellows seals downstream pressure from loading pressure

Not content with the enviable performance record of the Type 92A, Fisher engineers have improved this pilot operated pressure reducing valve to a new peak of performance.

For extremely accurate, long trouble-free service, put a Fisher 92B in the line. One pilot with three interchangeable springs provides a range of from 2 to 150 psi. • *Send for Bulletin D-92 today.*

Engineers with special problems . . . find the ***answer*** *in . . .*

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario

FISHER® Controls

For more information circle **56** on inquiry card.

Panhandle Pete

Introducing the Logger-Scanner

As all our avid readers know, WESCO! has just finished its first systems job at the Atlas Electronics, Coke and Petroleum Company, comprising an Aves analyzer on the main byproducts gas line, an O. J. computer in the engineering department, and a high-speed data logger (730,000 words microsecond) closing the loop. "Let's go down to Atlas and take some pictures of our first system and then produce some elegant brochures to show the rest of American industry how well we do this sort of thing," says Waldo, our genial sales manager.

So Waldo, our photographer and I drive down to Atlas, where we get a shock—nobody can find the Head of the Instrument Department, our good friend Jim Curley, since the system went into operation.

Just then Waldo notices a double row of freight cars circling the main office.

"What's in that long row of freight cars," asks Waldo of Atlas' Chief Engineer.

"That's where the logged data is kept until we can build a new data center," yells the Chief Engineer above the roar of the noise made by coupling two more cars on the string.

At which point Waldo gets a queer glint in his eyes and starts rummaging through the freight cars, and low and behold, in the third car he finds Jimmy buried under a ton of papers.

"You guys found me just in time, says Jimmy—and you better do something about using the mass of data you are logging. Next time somebody gets caught under that pile it's liable to be fatal."

Back at the plant we immediately call a staff meeting to face this serious situation. Otto, Waldo, and I sat glumly thinking about the seriousness of this situation—after all, we don't get paid until Atlas is satisfied according to that lousy contract our rep made with Atlas—when Otto suddenly beams, "I have it. In fact, like all problems, this one faces every scanner-logger user, and our solution is universal. WESCO! again comes up smelling like a rose."

"Let's not keep this thing a secret, Otto," says I.

"Of course not," says Otto. "The problem is simply one of evaluating a mass of data being logged by a scanner-logger."

"This is new?", says I.

"No, but our solution will be," says Otto. "What the scanner logger needs—in fact, what every scanner-logger needs is a logger-scanner. This is a scanner that scans the logger, picking up only what is valuable and discarding the rest."

"But how will the logger-scanner know what data to pick up and what to discard?", says I, warming to this proposition.

"Easy," says Otto. "All we do is incorporate a computer which makes the basic decisions as to which data is needed or not."

"Otto Uber Alles, you are truly American genius at work," says I, rushing off to let all the editors of the trade press in on this newest development in the field.

Panhandle Pete

automation comes to tape-winding

A better method... a better machine... for automatically winding perforated, communications, computing or accounting tape.

The Cycle Universal Tape Minder is made to satisfy all the demands of modern tape handling techniques. Power driven, static-free, service-free, intermittent winding for any tape minding chore. Tape-minder installations reduce operating costs. The first cost does the job.

Write for descriptive literature, form # IA-3

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Do you think of pressure transducers?

AI

ATOMICS INTERNATIONAL
DIVISION OF NORTH AMERICAN AVIATION, INC.

does... and uses Statham pressure transducers as part of the control instrumentation in the construction of its nuclear reactors which open entirely new fields in industrial research and development by providing an on-the-spot source of high-energy gamma rays and neutrons.

WHEN THE NEED IS TO KNOW... FOR SURE SPECIFY STATHAM

Accelerometers
Pressure Transducers
Load Cells

Catalog, complete with prices, available upon request.

Statham
INSTRUMENTS, INC.
LOS ANGELES 64

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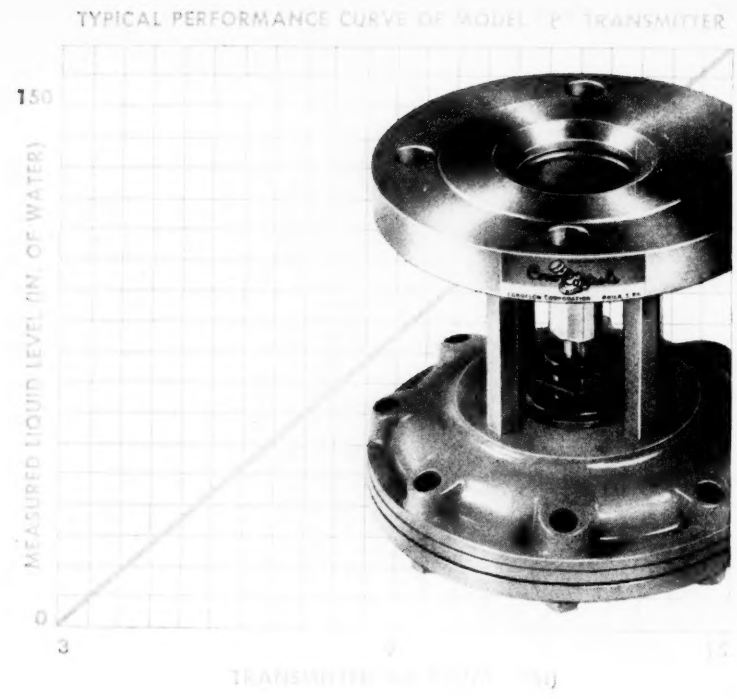

NEW

CONOFLOW

LIQUID LEVEL & PRESSURE

TRANSMITTER

WITH

Exclusive

ISOLATED MEASURING DIAPHRAGM

The Conoflow Model "P" Transmitter is a rugged instrument which measures pressure and liquid level and transmits a *linear* 3-15 psi signal to standard receiver elements. Incorporates these cost-saving features:

Safety—Process liquids and gases cannot back up through air lines and damage costly instruments. This is guaranteed by the complete separation of measuring diaphragm from pneumatic pilot.

Simple Installation—The Model "P" can be mounted either horizontally or vertically on open or closed vessels. No dip tubes, floats or other mechanical devices are required inside the tank.

Long Life—Only the corrosion-resistant *Inconel X* diaphragm is exposed to the measured material. Preformed diaphragm will not work-harden or fatigue; withstands pressures to 500 psi and temperatures to 450°.

Versatile—Can be used for practically any service; ideal for viscous fluids or materials with solids in suspension; also for flowing bulk materials such as pigments, flakes, etc.

Choice of Ranges—Available for measuring ranges as low as 0 to 100" of water and pressures as high as 250 psi. Ranges can be changed in the field.

Specifications—Bulletin P-2520-3 contains complete specifications on the Conoflow Model "P" Transmitter. Write for your copy today or let us quote on your requirements. No obligation. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa.

CC-802

Cono-Controls®

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

SUBSIDIARY OF WALWORTH

For more information circle **59** on inquiry card.

events

March 26-27

Instrument Ball Bearing Conference, of New Departure, Hotel Statler, Cleveland, Ohio. For information contact New Departure, Bristol, Conn.

March 26-28

20th Annual American Power Conference sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago. For information write to Illinois Tech, 35 W. 33rd St., Technology Center, Chicago 16, Ill.

April 1

Tenth Annual New Jersey Symposium on Control Systems Engineering, sponsored by N. J. Section of ISA, Newark, N.J. For information write Warren S. Jones, Secretary, c/o J. Arthur Moore Co., 342 Madison Ave., New York 17, N. Y.

April 2-4

4th Annual ASME Instruments and Regulators Conference sponsored by ASME, AICE, IRE, ISA, AIEE, University of Delaware, Newark, Delaware. For information write L. S. Dennegar, ASME, 29 West 39th St., New York 18, N. Y.

April 14-16

Joint Conference on Automatic Techniques of the AIEE, ASME, and IRE, Hotel Statler, Detroit, Mich. For information write IRE, Inc., 1 East 79 St., New York 21, N. Y.

April 16-25

International Instruments, Electronics & Automation Exhibition, Olympia, London. For information write T. E. Rees, 9 Argyll St., London, W. I., England.

April 17-18

Second Annual Meeting of the Institute of Environmental Engineers, New Yorker Hotel, New York City. For information write Institute of Environmental Engineers, 9 Spring Street, Princeton, N. J. (Ray H. Mattingley).

April 22-24

Electronic Components Conference, Ambassador Hotel, Los Angeles. For more information write David M. Knox, Packard-Bell Electronics Corp., 12333 W. Olympic Blvd., Los Angeles 64, California.

April 24-26

Spring Meeting of U.S.A. National Committee of the International Scientific Radio Union and Institute of Radio Engineers, Willard Hotel, Washington, D.C. For information write IRE, Inc., 1 East 79 St., New York 21, N. Y.

May 1-8

26th Annual Meeting of American Society of Tool Engineers, Convention Center, Phila., Pa. For information write Richard Gebers, Public Relations Mgr., 10700 Puritan Ave., Detroit 38, Mich.

a commercially profitable atmosphere for buyer and seller

Through its exhibits and meetings the show and congress can perform a valuable educational service while providing a commercially profitable atmosphere **for both buyer and seller.**

Program for the Exposition and Congress promises satisfaction for visitors and exhibitors alike. A partial list of reasons is at left.

And, since the National View is focussed squarely on technology—and our supremacy to get there fast, first, and with the most, under serious challenge—this fourth edition of the "original" automation show becomes even more important to individual and industry.

ALL-STAR CHECK LIST
for prospective exhibitors and visitors—

★ **One all-inclusive "package" price for exhibitors ($5.00 sq. ft.) covers most "fringe" services for which exhibitor usually pays extra.**

★ **Attendance expected to top 25,000 executives, engineers, and technicians.**

★ **Exhibitor-sponsored Clinics on:**
- ★ Electronic Computers
- ★ Process Automation
- ★ Machine Tool Automation
- ★ Office Automation
- ★ Automatic Materials Handling
- ★ Servomechanisms
- ★ Electromechanical Components
- ★ Electronic Components

★ **Automation Congress comprising eleven sessions:**
- ★ Data Acquisition and Reduction
- ★ Automatic Weighing
- ★ Medical Instrumentation
- ★ Automatic Control Valves
- ★ Military Electronics and Controls
- ★ Importance of Measurements
- ★ Design for Automation
- ★ Education for Automation
- ★ Manufacturing and Automation
- ★ Contribution of Cybernetics to Automation
- ★ Foreign Developments in Automation

★ **Four Technical Sessions of American Society of Mechanical Engineers, Material Handling Division:**
- ★ Automatic Warehousing
- ★ Automatic Materials Handling Systems in Small Plants and Warehouses
- ★ Automation on the Production Line
- ★ Systems Engineering, Economy & Justification

★ **Three 2-day Conferences for top-level executives:**
- ★ Human Factors in Systems Engineering
- ★ Plant Layout for Automation
- ★ Maximizing Profits and Utilization of Capital

FOR COMPLETE DETAILS, WRITE:

RICHARD RIMBACH ASSOCIATES
845 RIDGE AVE., PITTSBURGH 12

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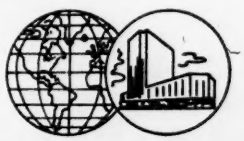
4th international AUTOMATION EXPOSITION

and concurrent
MILITARY AUTOMATION EXPOSITION



NEW YORK COLISEUM
JUNE 9-13, 1958

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
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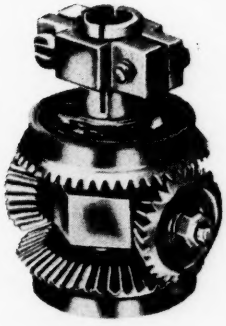
STERLING *Precision Components* from stock



Differentials
8 types of stock differentials from swing circle .600 to 1.187 and shaft sizes 1/16" to 1/4"

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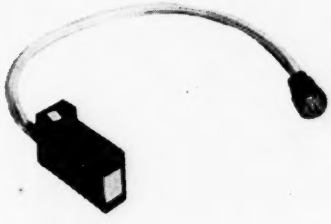
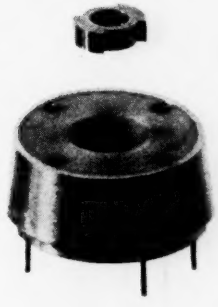
All types of gear heads for all BuOrd servo motors

Magnetic Clutches
25 different types of stock clutches in both 1 1/16" and 1 3/4" case size diameters

Gear Trains
All precision miniature and subminiature types for servo loops



"E" Coils
Accurate to 1 second of arc — used in position pickoff in servo rate or optical systems



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Both signal and torque types available.
1 1/2" & 2" microsyns for Hig 4 & Hig 5 gyros
Engineering report ER-115 available

In the field of precision gear-working, Sterling offers the most complete line of precision gears and servo-motor geartrains available — including spur and anti-backlash types. No waiting, either, because these competitively priced units (some of which are illustrated above) are immediately available from stock in standard or breadboard experimenter's kits.
Sterling, the country's largest contract manufacturer of gyro test equipment, invites you to see how its components can put precision into your electromechanical designs. If your requirement cannot be met from our comprehensive line of shelf items, we custom-design to your specs.

Write or phone for catalog sheets covering particular product requirements.

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INSTRUMENT DIVISION
17 MATINECOCK AVE., PORT WASHINGTON, NEW YORK
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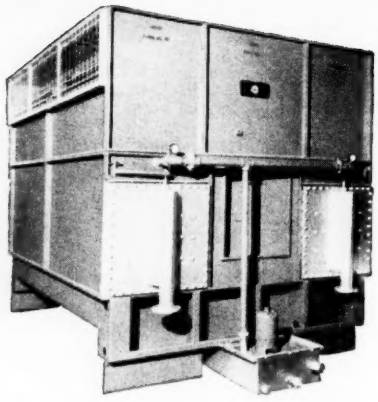
COMPLETE LINE AVAILABLE FOR COMPUTER AND CONTROL ENGINEERS



Is your plant CRITICALLY SHORT of WATER?

● You will make major water savings, reduce your costs, solve your problems of water supply or disposal and get HIGH OPERATIONAL EFFICIENCY with Niagara "Areo" Evaporative Heat Exchangers, After Coolers or Condensers for these important plant services or processes:

- **AFTER COOLING and air drying for large air and gas compressors and AIR LIQUEFACTION**
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- **VAPOR CONDENSING UNDER VACUUM**
- **ELECTRONIC PROCESS COOLING**

High operational efficiency means: precise temperature for improved product and process quality control, heat removal at rate of input, simple operating conditions, real economy in upkeep, sustained full capacity.

Also it means cooling in a closed system with your product kept free from contamination or, when condensing, getting a pure condensate holding high quality in your product or material.

Niagara machines do the work of a cooling tower plus shell-and-tube coolers with a single machine that saves piping, water handling disposal and treatment expense and 95% of water consumed by contact cooling methods.

Write for Bulletin 129, 130, 132, 136R.

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District Engineers in Principal Cities of U. S. and Canada

For more information circle **62** on inquiry card.

EVENTS—CONTINUED

May 6-8

1958 Western Joint Computer Conference of the Institute of Radio Engineers and the American Institute of Electrical Engineers, Ambassador Hotel, Los Angeles. For information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

May 12-14

4th National Instrumental Methods of Analysis, ISA Analysis Instrumentation Div. & Houston Section, Shamrock Hilton Hotel, Houston, Texas. Contact R. D. Eanes, L&N Stenton Ave., Phila. 44, Pa.

May 21-23

Instrumentation & Automatic Control of Power Systems—Today & Tomorrow, ISA Power Div. and the New York Section. Contact W. Welch, Long Island Lighting Co., L. I., N. Y.

May 31-June 8, 1958

European Congress of Chemical Engineering and ACHEMA Congress, Frankfurt a.m., Germany. For information write DECHEMA, Dechema-Haus, Rheingau-Allee 25, Frankfurt a.m., West Germany.

June 2-4

1958 National Telemetering Conference sponsored by the A.I.E.E., A.R.S., I.S.A. and I.A.S., Lord Baltimore Hotel, Baltimore, Md. For information write T. E. Meyers, Wolfe & Mann Mfg. Co., 28th & Sisson St., Baltimore 11, Maryland.

June 9-13, 1958

Fourth International Automation Exposition, Congress, Conferences, and Clinics, New York Coliseum. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

July 14-25

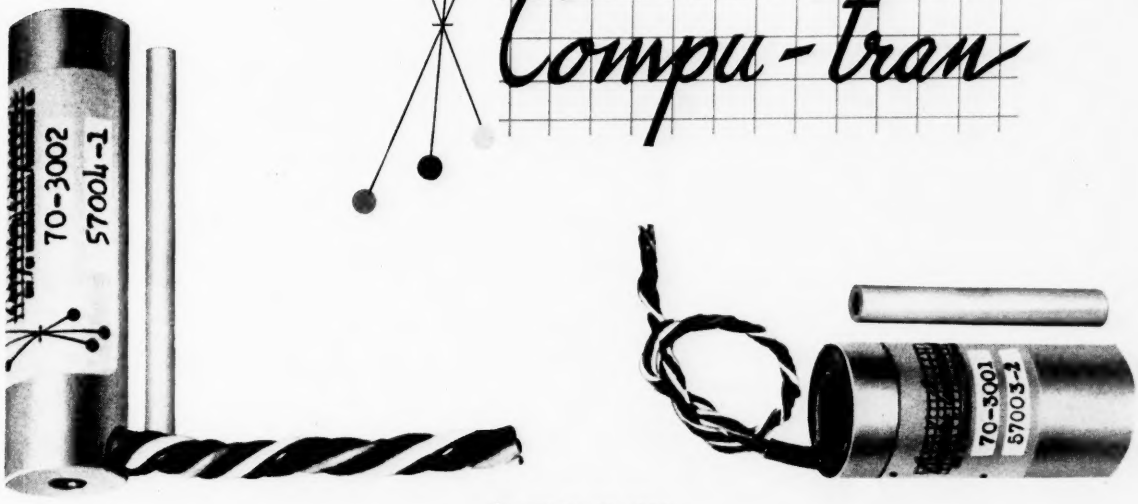
Special Summer Program in the Physics of Infrared Radiation, Massachusetts Institute of Technology. For information write Dr. Richard C. Lord, Dir. of Spectroscopy Laboratory at M.I.T.

July 28-August 1

Gordon Research Conference on Instrumentation, Colby Jr. College, New London, N. H. For information write Dr. W. George Parks, Dir., Dept. of Chemistry, University of Rhode Island, Kingston, R. I.

Oct. 13-15

1958 National Electronics Conference—the 14th Annual Forum on Electronic Research, Development and Application sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, and Northwestern and Illinois Universities, Hotel Sherman, Chicago. For information write National Electronics Conference publicity chairman, c/o Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.



IRC SERIES 70-3000

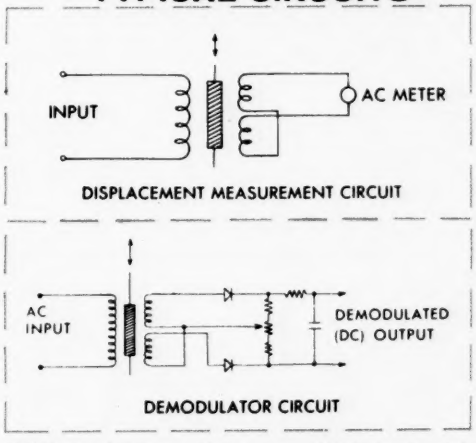
DISPLACEMENT TRANSDUCER

The IRC Displacement Transducer offers many new advantages, including lower cost. Its higher sensitivity and 0.1% linearity is specially suited to military instrumentation applications. The output is completely stepless and null voltage is 0.25% or less of total output. In addition, the output of standard IRC Displacement Transducers is high ...2 MV/Volt Input/Mil; all offer high output voltage in relation to size. Input voltages can be obtained up to 110 v. AC.

Compu-Tran Displacement Transducers show high resistance to moisture and shock . . . are available in 23 standard and sub-miniature sizes with a temperature range of −65 to +225°F. Also, IRC's Compu-Tran Displacement Transducers are the only units available completely encapsulated in a protective unit.

Designers of accelerometers and other measuring, indicating, gaging and process control devices will be especially interested in Compu-Tran Bulletin R-3. Write for your copy today.

TYPICAL CIRCUITS



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MODELS COVER RANGES FROM 0 TO 200 M.P.H.

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Hastings Model G Air-Meter. Velocity range: 0-6000 fpm. May be used ideally in usually inaccessible areas.

Hastings Model B Precision Air-Meter for measurements of highest accuracy. Dual-scale meter with range up to 20,000 fpm. Directional or non-directional probes.

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Manufacturers of Hastings Vacuum, Pressure, Velocity and Flow Measuring Instruments
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9 TMI memory for UFMA computer

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80T1 for high speed, tube driver memories
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50T1 for super-speed, tube or transistor driver memories
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SUPER-FAST, HIGH PRECISION

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WITH BAIRD-ATOMIC
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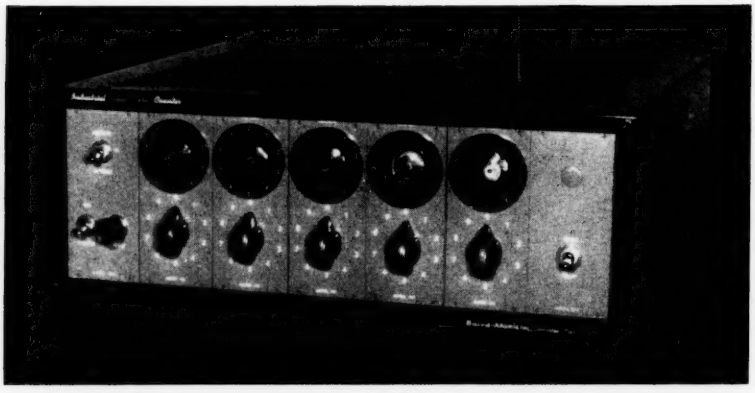
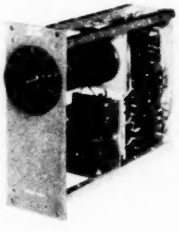


Many standard and special models available for counting, sorting, machine cycle, unit flow, packaging and other industrial and control applications.

Electronic speed and accuracy with up to 20,000 unit counts per second. DEKATRON* cold-cathode glow transfer tubes give constant visual reference to total count.

DEKATRON* TUBES AVAILABLE SEPARATELY

The DEKATRON cold-cathode glow transfer counting tube used in B-A instruments requires far less power than "hot" tubes. DEKATRON tubes permit simplified circuitry with fewer components than ordinary tubes resulting in greatly increased reliability. The moving glow spot within the tube indicates total and eliminates the need for additional indicating lights. Baird-Atomic is the sole distributor of DEKATRON tubes in the United States and Canada.



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Unitized plug-in strips with DEKATRON tube, numbered bezel and drive circuitry are available in many functional types. These B-A plug-in strips save assembly time and permit the customer to more easily incorporate the counter into existing panels or equipment.

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BOOK Reviews

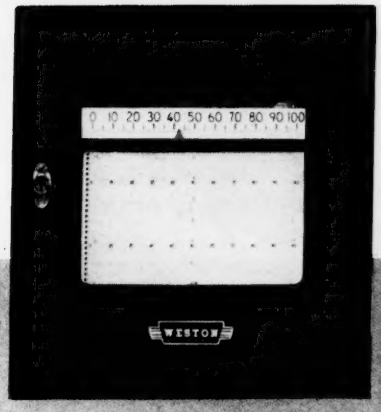
Automatic Control Technology. Modern Theories and their Usefulness. 433 + XV pages, 1957, 898 illustrations and 43 tables. Includes 90 advanced papers on control technology, as delivered in original language (English, French, German, Russian; all Russian papers are translated into German; about ½ of book is in English), 9" x 12". Handsome cloth binding. $24.00. Printed by R. Oldenbourg Verlag, Munich, Germany. American publisher, Instruments Publishing Company, 845 Ridge Ave., Pittsburgh 12, Penna., U.S.A.

The book is a report of the Heidelberg Meeting, September 25 to 29, 1956, arranged by the VDI VDE-Fachgruppe Regelungstechnik with the cooperation of the Fachausschuss Regelungsmathematik der Gesellschaft fuer angewandte Mathematik and Mechanik (GAMM); edited by Gerd Mueller, for VDI VDE-Fachgruppe Regelungstechnik.

Encyclopedia of Instrumentation for Industrial Hygiene, edited by C. D. Yaffe, D. H. Byers and A. D. Hosey, 1956, Univ. of Michigan, Ann Arbor, Mich. 1243p. $22.50. 12 in. A comprehensive illustrated treatise on the measurements essential in industrial hygiene. Most of the instruments discussed were exhibited at symposium at the University of Michigan in 1954, but other manufacturers are listed in the appendix. Papers by many authors are closely restricted to instrumentation, and deal with sampling and analysis of air, evaluation of atmospheric pollution, metering and measuring velocity of air, and with measurement of sound, vibration, ionizing radiations, and ultraviolet, visible, and infra-red energy. Appendix includes many valuable tables.

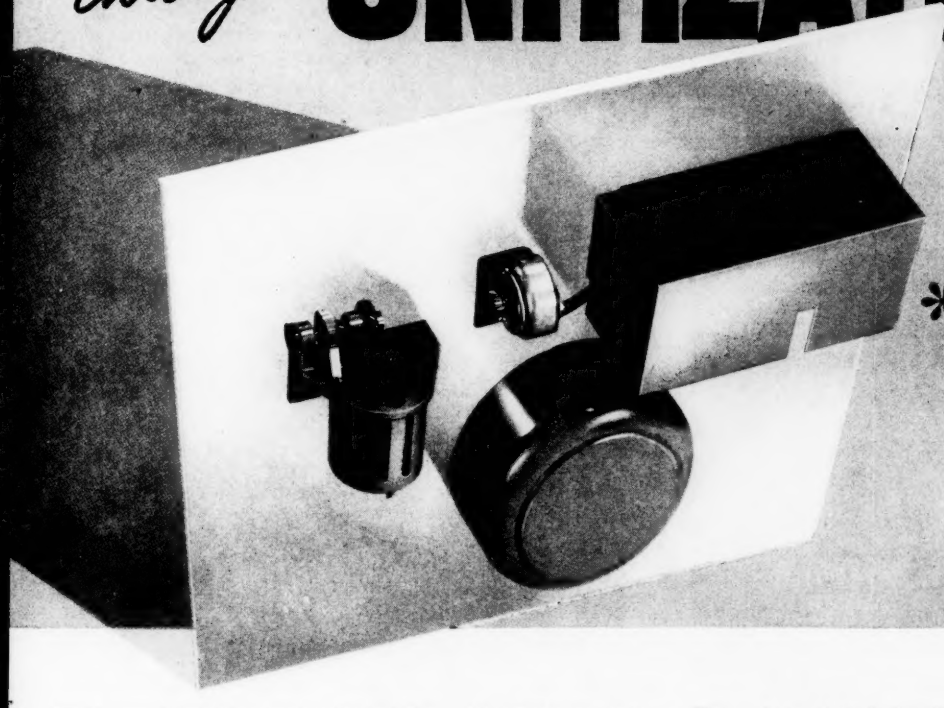
Strain Gage Techniques. Dr. W. M. Murray and P. K. Stein. 657 pages, 1957, Society for Experimental Stress Analysis, P. O. Box 168, Cambridge, Mass., $13 (two volumes). Covers fundamentals and applications, including basic considerations, mechanical aspects, electrical aspects, potentiometer circuits, bridges, balancing, amplifiers, and various application considerations. Books are specially prepared for two 2-week courses in Strain Gage Techniques offered each year in July at MIT and in August at UCLA. Over-run is made available for sale by SESA.

DAYSTROM-WESTON
MULTI-POINT
POTENTIOMETER RECORDER



Simplest . . . most efficient . . . easiest to maintain . . .

through UNITIZATION*



***UNITIZATION:**

the grouping of related components — in Daystrom-Weston Potentiometer Recorders — in the simplest, most serviceable, most efficient manner.

This versatile instrument collects information from as many as 24 sources, sorts it, and prints it with high accuracy in the form of up to 24 independent, simultaneous records. These functions are complex. But the instrument which performs them is neither complicated, cluttered nor delicate . . . thanks to Daystrom-Weston's UNITIZED DESIGN.

Parts are kept to a minimum, and integrated into compact, easily accessible panels. Spare-parts inventories are greatly reduced—due to interchangeability of components. There is no jungle of wires to hamper inspection and maintenance.

Routine servicing takes only seconds. Adjustments and circuit changes are made easily and without interrupting operation. All parts are designed for strength and shock resistance . . . to maintain alignment throughout years of hard usage. The unique etched circuit switch is geared to the printing head . . . can't get out of synchronization. Up to 6 general or selective alarm contacts can be added in the factory or field.

You see above, the unitized measuring-selecting panel of the multi-point instrument. In most other respects, this recorder is identical in construction, and offers the same advanced performance and maintenance features as the DAYSTROM-WESTON SINGLE-POINT POTENTIOMETER RECORDER and RECORDER-CONTROLLER.

For full information on any of these instruments, call your local WESTON Representative, or write to WESTON Instruments, Division of Daystrom, Inc., Newark 12, N. J. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.

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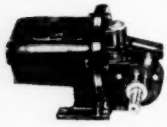

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All Voltages.

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Motors engineered to your specifications with 5 day delivery.

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Various Windings & Enclosures, such as Torque Motors, High Speed, Series Wound, 2 Speed Synchronous, Explosion Proof, etc.

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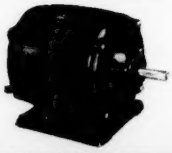

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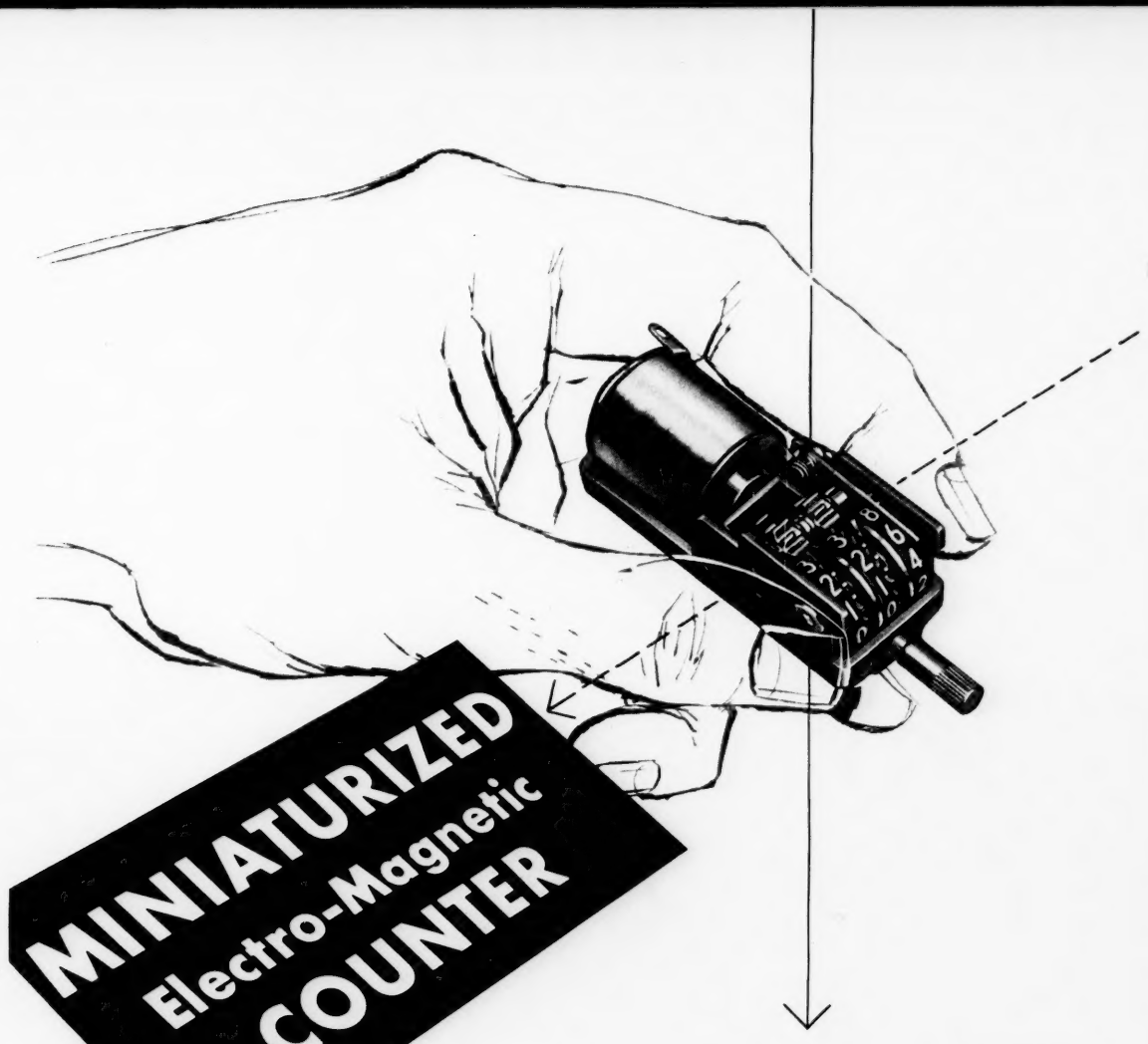

MINIATURIZED Electro-Magnetic COUNTER

Newest News from VEEDER-ROOT

Series 1527 Veeder-Root Miniaturized Electro-Magnetic Counters were originally developed for use in aerial cameras. These and similar counters are used to "post" the number of film-exposures, gallons or rounds of ammunition remaining after each use.

The new miniaturized counters present a frontal area less than 1" x 1" . . . save an important amount of space over the older, larger counters. Yet they are designed to operate at speeds as high as 900 counts per minute. And this modern design includes a new push-in bi-directional reset knob, with speed-up gearing. Specifications meet most military requirements. Write for full details.

Added Evidence that Everyone Can Count on

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For more information circle **71** on inquiry card.

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with DeZurik
Control Valves!

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Excellent control characteristics
Straight thru flow (reduces erosion and turbulence..... much higher flow capacity than globe type valves)
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The low cost design of DeZurik Control Valves makes it possible to furnish them with a positioner at a cost very often less than an ordinary valve *without positioner!* DeZurik Control Valves are available in sizes ½" thru 20" and in a wide choice of materials. Representatives in all principal cities or write for details.

DeZURIK CORPORATION
SARTELL, MINNESOTA

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NOW MEASURE FASTENER LOADS ACCURATELY AS THEY ARE TIGHTENED with

PIC Load-Sensitive Bolts

A positive and accurate method of measuring loads *as they are tightened.* Special resistance-type strain gauge, potted axially, gives reading direct in lbs. Use to distribute loads evenly in bolt groups, or for testing or design work. Available on order in most bolt, screw, or rod sizes and materials. Write for information.

PIC Polyphase Instrument Co.
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Today, on a multi-million dollar airplane, practically all the electrical and electronic control systems are designed on a modular or "black-box" basis. Using Cannon Connectors for quick plug-in and quick disconnect, defective control elements may be replaced in seconds... and the aircraft usually returns to flight before the defective units get to the shop.

Are the controls in your electrical or electronic product designed on the modular basis? How about your production line? Will a minor failure cause breakdown of the entire automated system that takes hours of down time to repair? Or are the controls of your product... and those in your plant... designed so that defective units anywhere may be disconnected and instantly replaced?

Cannon makes over 27,000 different electrical connectors. If one of these does not meet your requirements, we'll design and make the connector you need. Write today! Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. Please refer to Dept. 419

Send for explanatory material on how modular designs can save dollars.

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Where Reliability for Your Product Is Our Constant Goal

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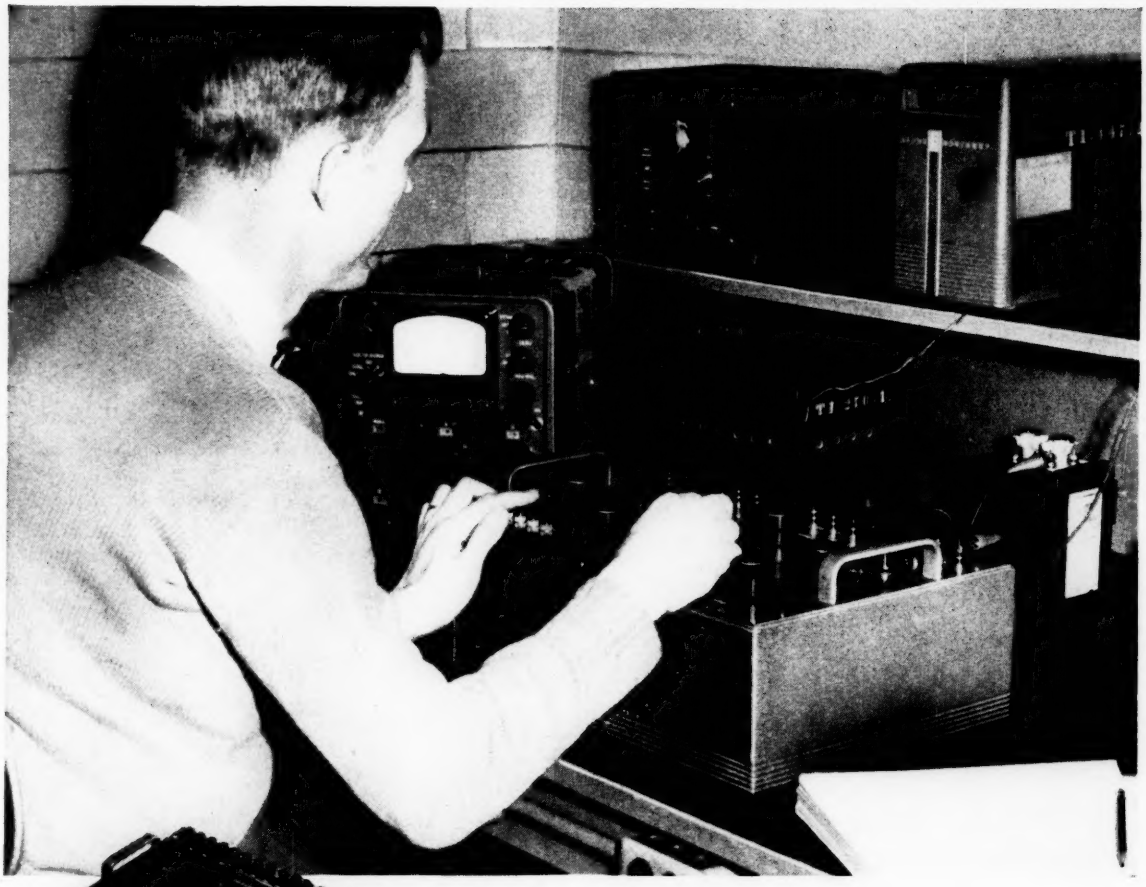
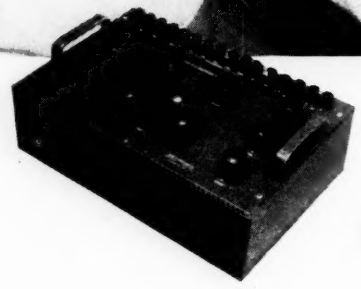




New Type K-3 Potentiometer keeps Melpar's radar test gear "on the beam"

Obtaining a high electrical accuracy is vital when designing and producing radar and fire control devices, analog and digital computers, etc. Melpar Inc. at Falls Church, Va., a subsidiary of Westinghouse Air Brake Co., relies on L&N's Type K-3 Universal Potentiometer as the prime d-c measuring instrument for their entire plant. The K-3 inter-compares standard cells calibrated by the National Bureau of Standards. Then, using these cells as reference, it calibrates the accuracy of voltmeters, ammeters and wattmeters used throughout the plant to check this complex electronic equipment.

This heavy workload of checking standards and instruments is easily handled by the K-3 because, as the head of the Quality Control Laboratory at Melpar says, its new design and convenience features permit "faster readings . . . and human errors are avoided because of the K-3's central reading window and decimal point indication of range. It is also much easier to standardize."

With these features, plus others such as the instrument's guarding against static and leakage, its built-in auxiliary potentiometer, etc., this Type K-3 will give you more accurate emf measurements in less time. Why not investigate the possibilities of this advanced potentiometer today. Write for the six-page Data Sheet E-51(6) on the K-3 from Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS Instruments **NORTHRUP** Automatic Controls • Furnaces

For more information circle **76** on inquiry card.

editorial

A Show Becomes A School

"I want to thank you for helping to introduce me to the computer and data logger fields so dramatically. I enjoyed it thoroughly—and look forward to your future expositions."

THUS did one of the 1000 registrants to the hundreds of clinic classes held at the Third International Automation Exposition acknowledge the unique and powerful education process developed by the International Automation Expositions, a technique now being adopted by other shows in the field. The concept is simplicity itself—for three hours of every day the exposition is closed to the visiting public, and becomes a school in which engineers and scientists sit in classrooms in front of the exhibited equipment, receiving 90-minute lectures on and demonstrations of modern techniques and equipments.

A show, with its crowds and milling masses, is not a classroom; and a classroom, with its 40 or 50 students is not a show. Each performs a basic and vital function in our field—the show brings the products of a manufacturer of equipment to the attention of thousands; each class (repeated four times) teaches perhaps a few hundred engineers the art and science of applying the equipment to the process or problem.

The first three Automation Expositions refined the technique for combining these two vital functions until, at the Third Exposition, no less than 972 registrants were accommodated in classrooms in the clinic hours of the Exposition. It is expected that an even greater number will benefit from the Fourth International Exposition, to be held at the New York Coliseum, June 14-17, 1958.

As in the past, the clinics sessions will comprise 1½-hour classes held in front of operating equipments. The illustrations show how this is done.

A partial list of exhibitors at the Fourth International Automation Exposition who are planning clinic sessions is on next page. More will be reported next month.

Only limited attendance is possible at each class. Advance registration will secure those classes desired by any individual, and a registration form will be sent to all applicants. Fee is $1 per class; registrant can select 2, 4, 6 or 8 classes. Two classes are given each day.

In the morning, a school . . .

In the afternoon, a show.

FIAE CLINIC CLASSES

THE ANALOG COMPUTER IN CONTROL SYSTEM DESIGN—Electronic Associates, Inc.
- The nature and capabilities of the analog computer
- Applying the analog computer to the design process
- Simulating a control system
- Demonstrations of typical problems

LOGICAL DESIGN AND DIGITAL TECHNIQUES—Computer Control Company
- Design of digital systems using block technique
- The logical element and logic mathematics
- Unitized logical elements

DIGITAL COMPUTER TECHNIQUES AND PRACTICE—Royal-McBee Corporation
- Digital computer elements and operation
- Instruction and programming
- Typical applications
- Demonstration and discussion of the LGP-30 general-purpose digital computer

DIGITAL COMPUTER PRINCIPLES AND APPLICATIONS—Bendix Aviation
- Elements of the general-purpose digital computer
- Instructions and programming
- Demonstrations and examination of the G-15 general-purpose digital computer and accessories
- Intercom 1000—a system offering floating decimal point arithmetic with fixed or floating point input and output.

OPTIMAL CONTROL OF CHEMICAL PROCESSES—Quarie Controllers
- Analysis of process characteristics—a disclosure of new techniques.
- Types of characteristic curves for chemical processes
- The Quarie Controller for optimal control.

COMPU-TRONICS—National Cash Register Company
- Disclosure of a new technique and new equipments

GAS ANALYSIS BY THERMAL CONDUCTIVITY—Gow-Mac Instrument Company
- Principles of gas analysis by thermal conductivity
- Types of cells
- Chromatography
- Typical applications and demonstrations

PLANT ECONOMICS WITH OPERATIONS RECORDERS—Gorrell & Gorrell
- Use of recorders for analysis of plant operations
- Economics of recording and analysis
- Multi-point recording
- Typical applications

WEIGHT, LOAD AND STRAIN CONTROL IN INDUSTRY—Baldwin-Lima-Hamilton Corp.
- Principles and practice of SR-4 techniques
- Applications in weight, load, torque, strain, etc.
- Current status of SR-4 devices in automation

FLOW MEASUREMENT AND CONTROL WITH TURBINE FLOWMETERS—Potter Aeronautical
- Principles of Pottermeter turbine-type flowmeters and related instrumentation
- Typical applications in flow measurement and control
- Calculations for mass flow, digital readout, etc.

PRESSURE CONTROL WITH PRESSURE SWITCHES—Gorn Electric Co.
- Principles and practice of pressure switches
- Selection and application factors
- Typical applications in aircraft and industry

POTENTIOMETER RECORDERS—The Bristol Company
- Principles of self-balancing recording
- Applications in industry and research
- High-speed self-balancing techniques

PHOTOGRAPHIC TECHNIQUES FOR AUTOMATION—Karl Heitz, Inc.
- Survey of photographic techniques
- Automatic techniques involving photography
- High-speed photography

LEVEL AND FLOW CONTROL—McIntosh Equipment Corp.
- Application of inexpensive on-off level and flow controllers

PRECISION ELECTRO-MECHANICAL COMPONENTS AND SERVOS—PIC Design Corp.
- Precision instrument systems using electro-mechanical parts
- Electro-mechanical servos
- Use of stock parts for precision systems

HIGH-TEMPERATURE HIGH-PRECISION COMPONENTS—Mycalex Corp. of America
- High-temperature printed circuits
- Mechanical commutation devices
- Ceramoplastic materials for high-temperature high-precision components
- Selection of materials

SERVO SYSTEMS—Waldorf Instrument Co.
- Servo system principles and practice
- Packaged servo systems
- Transistorized power supplies

SELECTIVE DATA PRINTERS—Copy-Craft, Inc.
- Survey of need for selective data printers
- Data printing techniques
- The Ormig selective data printer
- Typical applications

PROCESS SCANNING AND LOGGING TECHNIQUES—Pannelit Corp.
- The integrated process control system with scanner-logger
- New scanning and logging techniques
- Typical applications
- Built-in computing devices

MATHEMATICAL TOOLS FOR RAPID DATA ANALYSIS—Gerber Scientific Instrument Co.
- Applications of the variable scale in engineering problems
- Graphical-numerical computing devices and problems solvable on the GraphAnalogue—linear interpretations, frequency analysis, etc.
- Obtaining derivatives of curves
- Fitting equations to curves via the Equameter

CONTROL SERVO SYSTEMS—Waldorf Instrument Co.
- Servo building blocks for digital indicators, integral servo-driven analog indicators, analog-to-digital converters, etc.
- The "Micromation" concept

ELECTRO-MECHANICAL COMPUTER ELEMENTS—Waldorf Instrument Co.
- Miniature differentiators, integrators and vector solvers for typical analog computations

PRECISION DIMENSIONAL MEASUREMENT & CONTROL—Datex Div., G. M. Giannini & Co.
- Application of shaft-position encoders in the laboratory and in the machine-tool industry; principles and applications

OFFICE RECORDING TECHNIQUES—Miles Reproducer Co.
- The problem of conference recording
- Synchronized indexing, corrections, case histories

Fourth International Automation Exposition
845 Ridge Ave., Pittsburgh 12, Penna.
Please rush me advance-registration form and complete list of clinics at FIAE.

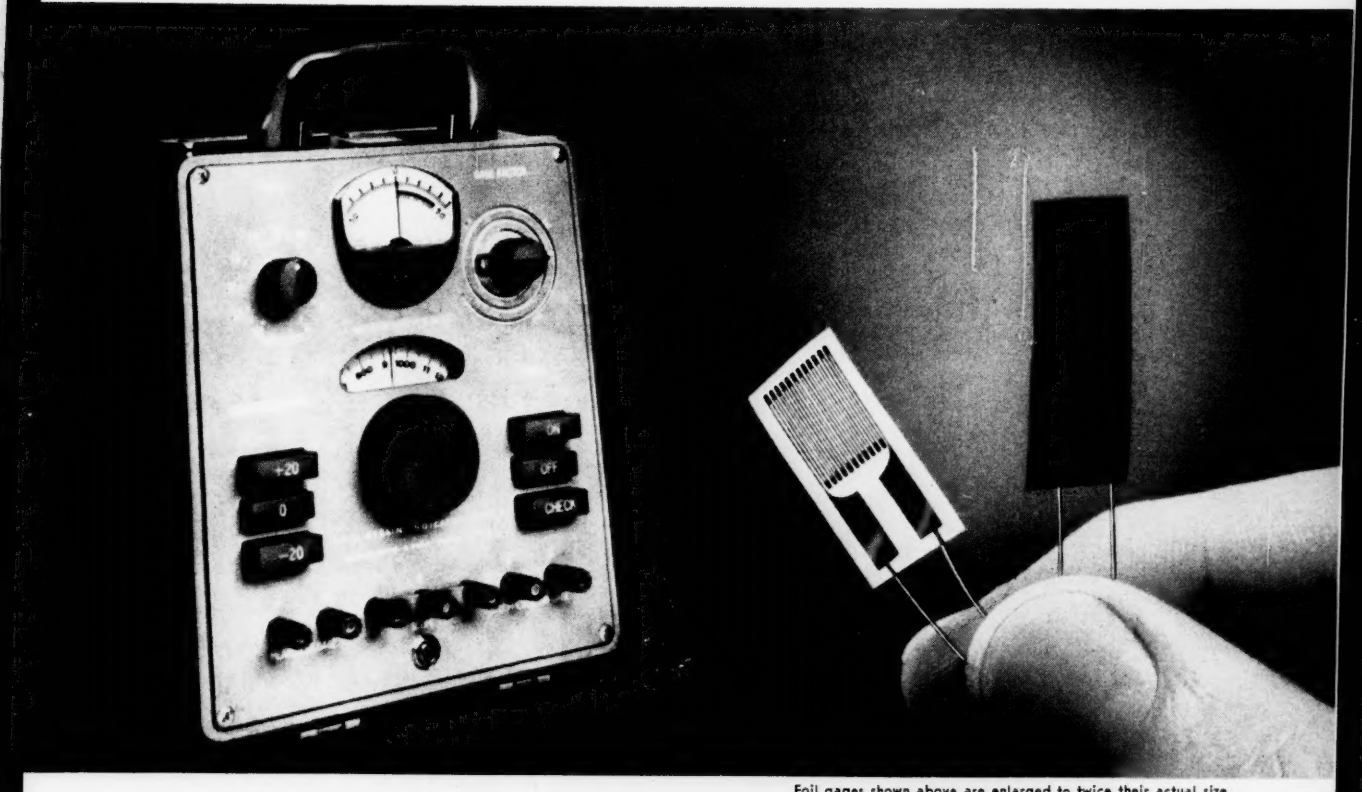
Name .....

Title .....

Company .....

Address .....

Newest strain-measuring equipment from Baldwin



Foil gages shown above are enlarged to twice their actual size.

NEW SR-4® strain indicator and NEW SR-4 bonded foil strain gages

Type N SR-4 Strain Indicator

This new, improved strain indicator features printed circuits and transistors, weighs one-third less than the previous model and has a smaller case. No warmup is required. In intermittent service its batteries last up to five times as long and cost two-thirds less. The legs of the case are positioned to permit tilting for improved readability. For direct readings with full external bridge, no calibration correction is required. Used as a preamplifier with standard cathode ray oscilloscope, it gives visual indication of dynamic strain with better response and in a broader range than the previous model. Frequencies up to 300 cps at amplitudes up to 3500 microinches per in. can be observed without appreciable distortion.

SR-4 Bonded Foil Strain Gages

Two new types of foil gage in ½ in. gage length, 120 ohms resistance, now make many types of stress analysis possible with new accuracy and ease. A Bakelite-bonded gage, Type FAB-2, and a quick-drying paper-and-cement-bonded gage, Type FAP-2, have marked advantages over comparable standard bonded wire strain gages. Hysteresis is now so low as to be negligible for stress analysis. Fatigue life of the paper gage matches that of comparable wire gages—that of the Bakelite gage is longer. Lateral strain sensitivity of both is down by one-half, offering new accuracy in measuring biaxial strains. The quick-drying paper gage is quick and easy to install. The Bakelite gage offers such attractive features as dependable service at 300°F or higher. It is thinner and more flexible than comparable bonded wire gages—requires no preforming for curved surfaces and is thus easier to apply. Its glass fiber filler makes it less sensitive to moisture effects.

Both new foil gages have tinned lead wires, well anchored and easy to connect. Both gages are now stock items for prompt delivery. For more information on this or other Baldwin stress analysis equipment, write to Electronics & Instrumentation Division of B-L-H, Waltham, Mass. Or we will have a representative call on you at your request.

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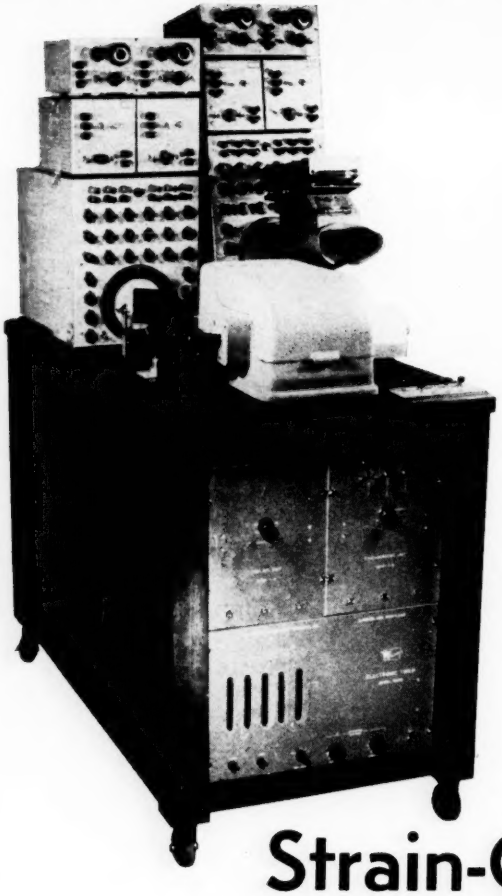
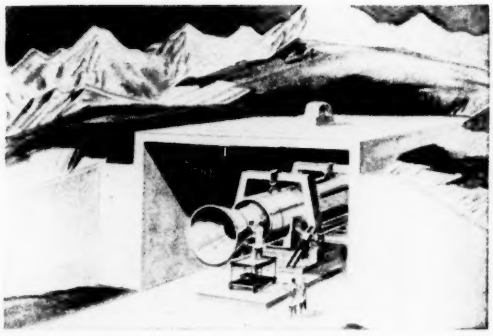
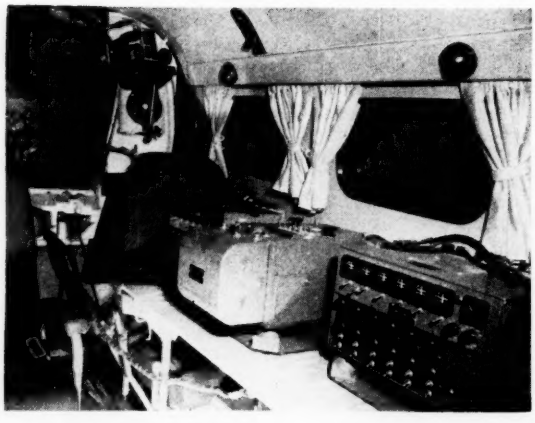


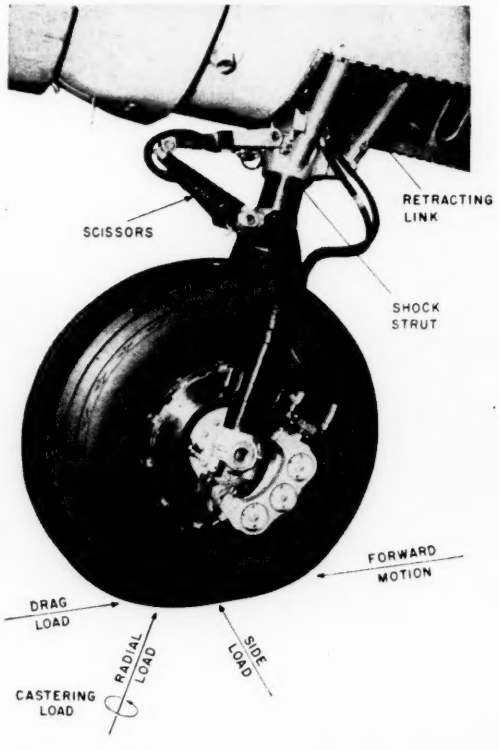


ROCKET-MOTOR TEST FACILITIES include equipments for testing propellants, configurations, discharge vents, etc. Hesse-Eastern of Cambridge uses a multichannel dynamic strain and temperature recorder (Allegany Instrument Company's ALINCO Model 204) which contains amplifiers and balancing equipment, automatic calibrators, dual-beam CRO, camera drum drive units, and complete control circuitry. A Land Polaroid Camera is shown on one scope.

Strain-Gage Applications



MORE THAN 100 SR-4 GAGES were used by Goodyear Tire Rubber Company, Wheel & Brake Division, to flight test landing-gear stresses. Locations for gages were determined by use of strain-indicating coatings. The instrumentation included a 12-channel S-12A Hathaway oscillograph, two 6-channel MRC-12 Hathaway switching equipments, and a 16-mm Cine Kodak Special movie camera trained on flight instruments.



Strain-Gage Principles

This introduction to resistance strain-gage work includes basic definitions, types of strain, member considerations, environmental factors, power supplies, bridge-balance techniques, and calibration methods.

M. A. LeGETTE
Consolidated Electrodynamics Corporation

TABLE 1—TYPICAL AVERAGE GAGE FACTORS AND TEMPERATURE COEFFICIENTS

Material	Gage Factor	Temp. Coeff. of Resistance ohms/ohm/°C	Apparent Stress (psi) per °C on Steel
Advance	2.1	0.0001	—30
Chromel	2.5		
Constantan	2.0	0.00001	
Copel	2.4		
Isoelastic	3.5	0.00047	2000
Manganin	0.47	0.00001	—400
Monel	1.9	0.002	8000
Nichrome	2.5	0.0004	2000
Nickel	—12.1	0.006	—13,500
Phos. Bronze	1.9	0.002	7800
Platinum	6.0	0.003	

STRAIN GAGES are transducers that are applied to the surface of materials in order to sense the strain of the material. The strain gage is elongation sensitive: that is, its electrical properties change proportionately to the elongation of the gage. Strain elongation (of the gage and the member on which it is mounted) is usually small as long as the applied stress does not exceed the elastic limit for a material. Stress is, by definition, the force applied divided by the cross-sectional area of the member:

$$Stress = F/A$$

An applied stress produces a strain (dimensional change) in the material. The relationship between stress and the resulting displacement is defined as Young's Modulus (E) where:

$$E = unit\ stress/unit\ strain$$

With stress expressed in pounds per square inch and strain in inches per inch, E has a value of 30,000,000 for steels. Thus a stress of 15,000 psi in a steel member produces a strain of only 0.0005 inch per inch of length. If we wish to measure stress of 4,000 psi with an accuracy of 1%, the strain gage must be sensitive to an elongation of 1.3 millionths of an inch per inch of gage length.

The most common form of strain gage consists of a short length of small-diameter (approximately 0.001" or 1-mil) wire of high electrical resistance. To keep the gage length short, the wire runs the length of the gage several times (Fig. 1). To simplify its mounting and to protect it, the wire is cemented between two thin pieces of paper. To apply the gage, it can be cemented to the member to be tested; this is a bonded resistance-wire strain-gage.

Strain, in engineering usage is defined:

$$Strain = change\ in\ length/original\ length$$

$$S = \Delta L/L$$

Strain gages indicate strain indirectly—that is, the length change is measured in terms of a resistance change. The method, although indirect, is precise—accuracies to 0.1% can be achieved. Coupled with this accuracy is great application flexibility.

Gage Factor

When the test member is strained, so is the bonded gage. As the wire is strained its electrical resistance changes. This resistance change is directly proportional to the strain in the wire, and the strain in the wire is directly proportional to the strain in the member.

Strain in a test member (S) is defined as $\Delta L/L$. The *unit* resistance change that the strain produces is defined as $\Delta R/R$. The relation between the unit strain and the unit resistance change is defined as *gage factor* (G). That is:

$$G = \frac{\Delta R/R}{S} = \frac{\Delta R/R}{\Delta L/L}$$

The gage factor (G) is the conversion constant between strain and gage resistance, and depends on the type of material used for the strain-gage wire. Manufacturers maintain close control on wire composition,

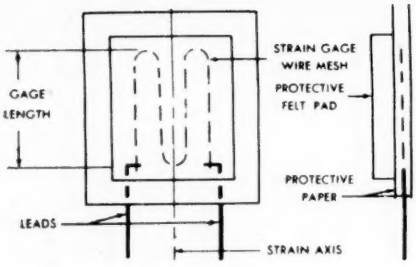


FIG. 1. SINGLE-GRID STRAIN GAGE is sensitive only to stress parallel to axis.

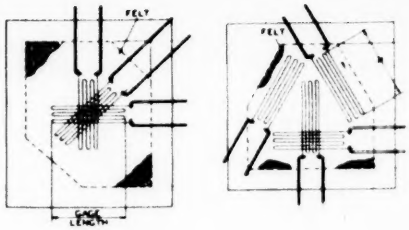


FIG. 2. ROSETTE GAGES. 45° rosette is shown at left; 60° rosette at right.

but the *measured* gage factor, stated on each package, should be used in all calculations. Table 1 gives some gage factors and temperature coefficients.

Note that the factor varies over a wide range, even having a large negative value for nickel.

The last column in the table shows the apparent stress produced by a change in temperature of 1 degree C for the gage on a steel member. This apparent stress is produced by the differential temperature expansion between the test member and the gage wire. To compensate for this effect a dummy can be mounted on unstrained material identical to the test member and exposed to the same environment.

To select the best type of gage for a specific application, it is necessary to consider the following:

Type of Strain

Area of Measurement. In use, each infinitesimal portion of the strain gage is intimately bonded to the member being tested and follows its movements in both tension and compression. It measures the average of the strains along the whole gage length. If strain in a localized area is needed, a short gage length must be chosen.

Amplitude. The expected amplitude of the stress determines the gage output at maximum excitation power. The amplitude (and frequency) of the output will determine whether sensitive galvanometers can be used directly, or whether amplification is required. Gages with high gage-factors can be obtained in certain frequency ranges.

Complexity of Stress. Single-grid strain gages are designed to measure only those strains parallel to the strain axis (Fig. 1). Transverse-axis sensitivity is generally less than 2% of the major-axis sensitivity. When strain directions are unknown, it is necessary to use a multiple array of gages disposed to permit later calculations of the magnitude and direction of the principal strains. To aid in this type of measurement, special multiple arrays called "rosette" gages have been developed and are available (Fig. 2).

Frequency and Duration of Strain. In general, two classes of strain work are encountered. The first is long-term examination of static or slowly varying forces, requiring a gage which gives consistent output under varying environmental conditions. While all strain-gage wire is specially selected and drawn to maintain uniform diameter, ductility, temperature coefficient, and resistance, static or "quasi-static" work requires a special wire with an extremely low temperature coefficient (1.0×10^{-5} ohms/ohm/°C). Such a wire has been developed under the trade name "Constantan." It is a copper-nickel alloy (60%-40%) and has a gage factor of approximately 2.0.

The other class of work deals with high frequencies, often at low amplitudes. This work requires wire of fatigue resistance and gages of high output, even at the sacrifice of long-term stability. For this, "Isoelastic" wire was developed. It is a complex alloy of iron (52%), nickel (36%), chromium (8%), manganese, silicon, molybdenum (4%), carbon, and vanadium (trace). It has a gage factor of approximately 3.5. Its temperature coefficient is 47×10^{-5}.

Type of Member

Thermal Conductivity. High heat conductivity of the test member may permit the gage to be operated at higher energizing power levels without danger of electrical overheating. Power levels of one watt are often used on massive steel and aluminum members. Power levels in the order of one-fourth watt should be used on plastics and small metal members.

Electrical conductivity. The cements normally used are insulating, but care must be taken against electrical leakage, particularly when mounting the gage on metals. Resistance to ground should be in the order of 200 megohms.

Ductility. Care must be taken not to strain the gage wires beyond their limit of proportionality. In general, they may be strained to 1% elongation (10,000 microinches/inch) without damage. Some are restricted to 0.7% elongation. "Post Yield" gages are available which will tolerate strains to 10%. (Note: 1% strain in steel approximates 300,000 psi).

Shape. The resistance-wire strain gage can be fastened readily to a curved surface, such as a pipe. With gage length as short as 1/32" available, even small-diameter tubing can be accommodated. Standard gages are protected with sturdy rag-bond paper. Where other considerations are not restrictive, the use of thin protective papers simplifies fastening to curved surfaces and shortens the cement drying time.

Environmental Considerations

High Temperature. Standard paper-base gages with nitrocellulose cement are serviceable to 130°F. For higher temperature, gages with the wires sandwiched between two paper-base Bakelite wafers are available. These will give continuous operation to 300°F, with limited service to 500°F. These gages must, of course, be fastened with Bakelite-type cement.

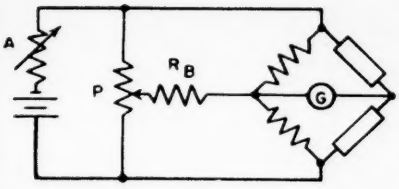


FIG. 3. **BASIC** balance circuit.

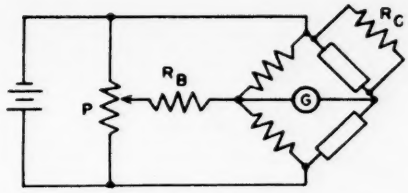


FIG. 4. **SHUNT** resistance calibration.

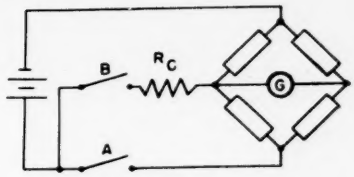


FIG. 5. **SERIES** calibration.

Low Temperature. At temperatures below −20 to −30°F. cellulose acetate cements tend to embrittle and impair the bond between member and gage. Bakelite gages and cements, serviceable at high temperatures, will perform at temperatures as low as −60°F. Moisture is an ever-present hazard at low temperatures, and to prevent excessive electrical "leakage," waterproofing the gage and exposed leads is necessary. Only low-temperature sealants are suitable. Type 1201, made by the Minnesota Mining and Manufacturing Company, is one which has been used successfully.

Temperature Changes. Changes in temperature will cause changes in resistance of the strain-gage wire. To the measuring instrument, this resistance change appears exactly like a strain. Several methods can be used to lessen or cancel this effect. Wire with a low temperature coefficient, such as Constantan or Advance, is one preventive. Special temperature-compensated gages, which practically cancel out temperature effects, are made to suit steel or aluminum structural members. Most common, however, are techniques which permit cancellation of temperature effects in the measuring instrument circuits.

Humidity. Although normal cementing techniques give adequate protection for most usage, high humidity demands special water-proofing treatment. Grease or wax coatings give good service for general humid conditions. For the utmost stability, the use of Bakelite gages and cements is recommended. Such gages, with leads waterproofed with Neoprene, give months of service, even under water.

Power Supply

The strain-gage bridge must be powered from a power supply whose voltage output does not change during the course of the test. Lightly loaded lead-acid or nickel-alkaline storage batteries are good. For applications where space or weight is a restriction, *mercury cells* (P. R. Mallory and Co.), *silver-zinc batteries* (American Machine and Foundry), or *Silvercels* (Yardney Electric Co.) are applicable. Following a short initial stabilizing period these cells maintain stable output from −30 to +200°F.

For critical applications in which very stable voltages must be provided for extended periods, electronic or magnetic stabilized power supplies must be considered. Such supplies provide levels to 15 volts, currents to 1 ampere, with regulation better than 0.1%.

The maximum voltage to be applied to a bridge may be calculated from $E = \sqrt{WR}$ volts, where W = permissible wattage between ¼ and 1 watt, depending on thermal inertia and cooling; R = bridge input resistance in ohms.

The minimum voltage is fixed by the sensitivity of the measuring instrument used and the maximum amount of strain expected. If the permissible bridge output is insufficient to drive the measuring instrument directly, then amplification is required.

Amplification

Both d-c and a-c amplifiers are available for strain-gage work. To overcome the inherent instability of d-c amplifiers, it is common practice to use carrier-amplifier technique in which the bridge is energized with ac. The a-c signal is amplified by a stable a-c amplifier and then demodulated by a phase-sensitive demodulator.

Bridge Balance

Due to resistive discrepancies or small initial strains induced into the gage wire during mounting, the bridge circuit will show a small zero-strain output when energized. To give zero output for zero strain this signal must be balanced out. Fig. 3 illustrates how this balancing is usually accomplished.

By attenuating the voltage applied to the bridge, a convenient value of galvanometer deflection per unit of strain can be obtained. Variable resistor A handles this function. Instruments containing multi-bridge balancing and attenuation components are available.

Calibration

True over-all calibration requires the imposition of known loads, under test conditions, to the complete measurement system. Unfortunately, in strain-gage work the application of such loads is often impractical. However, simple techniques are available which accurately simulate strains at the gages by means of analogous resistance changes.

The most widely used of these techniques is known as *shunt resistance calibration* (Fig. 4).

The attachment of registor R_c across the gage, as shown, reduces the resistance of that arm of the bridge. This is entirely analogous to the resistance change caused by a compression of the strain gage.

The calibrate resistor R_c also can be inserted in series (Fig. 4). Opening switch A removes the bridge excitation and gives a zero check. Switch B closes the circuit through R_c and gives a series calibration check free of disturbing transducer signals.

STRAIN-GAGE

Strain-gage instrumentation requires knowledge of (1) basic bridge circuits, (2) deflection-type indicators, (3) null-type indicators, (4) galvanometer considerations, (5) amplifier types and principles, and (6) strain-gage control units. Here is a thorough résumé of complete strain-gage instrumentation.

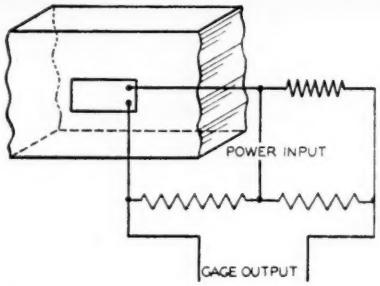


FIG. 1. BRIDGE made up of one strain gage and 3 fixed resistors.

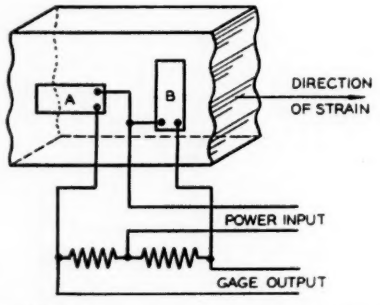


FIG. 2. BRIDGE made up of one active strain gage, one temperature-compensating gage, and two fixed resistors.

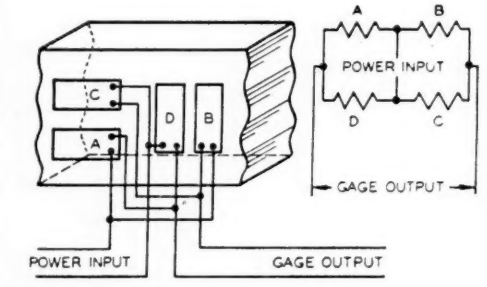


FIG. 3. BRIDGE made up of two active gages (A and C) and two temperature-compensating gages (B and D).

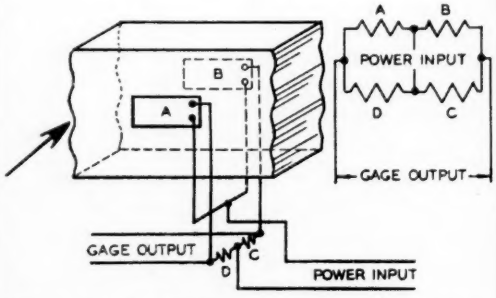


FIG. 4. TWO ACTIVE gages and two fixed resistors, temperature-compensated, sensitive to bending only (in direction of strain shown).

RESISTANCE STRAIN GAGES are almost always used in a bridge circuit to produce a voltage or current output that is a function of the gage resistance. The bridge may be made up of one strain gage and three fixed resistors, two strain gages and two fixed resistors, or four strain gages. Regardless of how the bridge is made up, it is highly advantageous for all four arms to be located close together at the point of strain measurement. There are several ways in which the bridge can be made up.

Basic Bridge Circuits

(1) *One gage.* The bridge can have one gage and three fixed resistors as shown in Fig. 1. As this arrangement does not provide temperature compensation, it is not applicable for long-time static measurements. It is useful for dynamic measurements where it is not necessary to measure static strain, or where static strain is of such short duration that temperature changes are slight.

(2) *One active gage, one compensating gage.* In Fig. 2, A is an active gage and B is a temperature-compensating gage mounted on the member so it will not measure strain. The other two arms of the bridge consist of fixed resistors. This arrangement provides temperature compensation and is useful for prolonged static and dynamic measurements.

(3) *Two active gages, two compensating gages.* The bridge can be made up of four gages—two active and two-compensating, as shown in Fig. 3. The compensating gages can be mounted either on the member itself in a zero-strain location, or on a separate plate. This arrangement provides an output twice as great as those shown in Figs. 1 and 2.

(4) *Two active gages for bending only.* Fig. 4 shows two active gages, sensitive to bending but not to tension, and with temperature compensation. Note: the bending must be in a direction to stretch one gage

INSTRUMENTATION

C. M. HATHAWAY
The Hathaway Instrument Div.
Hamilton Watch Co.

and compress the other, such as shown by arrow.

(5) *Two active gages for tension only.* When it is desired to measure tension only, the arrangement shown in Fig. 5 can be used. This circuit is insensitive to bending, but it is not temperature compensated.

(6) *Two active gages, two compensating gages, for tension only.* When it is desired to measure tension only, and when temperature compensation is necessary, the arrangement shown in Fig. 6 can be used.

(7) *Four active gages for bending only.* Four active gages can be used to measure bending only, as shown in Fig. 7. This circuit provides twice the output of that shown in Fig. 4, and is temperature compensated. Note: bend must cause A and C to change opposite to B and D, such as shown.

Deflection-type Strain Indicator

The strain indicator for resistance strain gages can be a sensitive microammeter or galvanometer connected across the output of the bridge (Fig. 8).

It is better practice to make up the complete bridge at the strain-gage location so that long leads and unsoldered joints are not included in the bridge circuit. The microammeter may, however, be located at a distance from the gage bridge because the leads to it are not included in the bridge circuit. The bridge can be conveniently balanced at the microammeter if a third lead is carried to the slider of the potentiometer p as shown in Fig. 8. If one more lead is included in the cable, the battery also can be located at the microammeter. The microammeter, battery, and balancing controls can be mounted in one case, and connections can be made to the strain gage by means of a 4-conductor shielded cable of any length desired.

The current in the microammeter or the galvanometer for a given strain can be calculated from:

$$I = SVGn/4(R+r) \text{ microamperes}$$

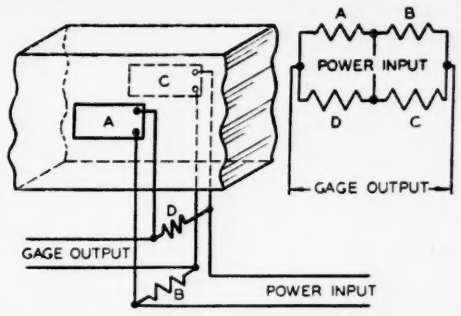


FIG. 5. BRIDGE made up of two active gages and two fixed resistors, sensitive to axial tension only, not temperature compensated.

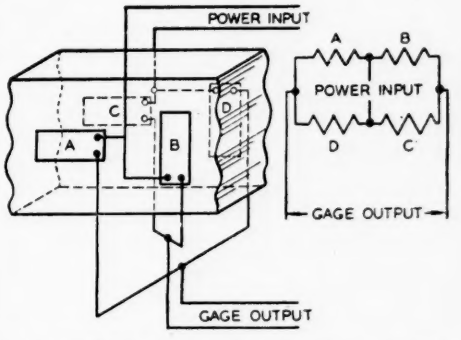


FIG. 6. BRIDGE made up of two active gages and two temperature-compensated gages and sensitive to axial tension or compression only.

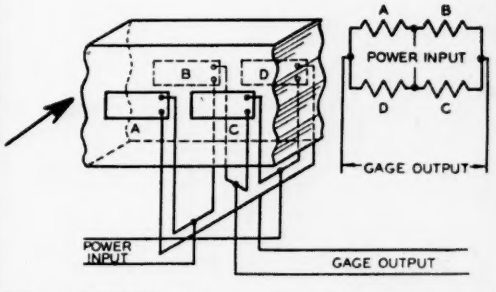


FIG. 7. BRIDGE made up of 4 active gages, temperature-compensated, sensitive to bending only.

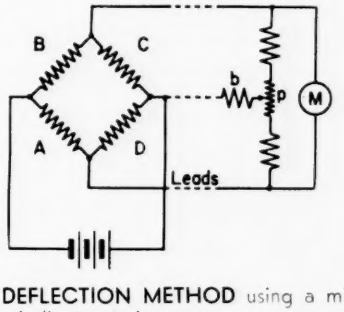


FIG 8. DEFLECTION METHOD using a microammeter to indicate strain.

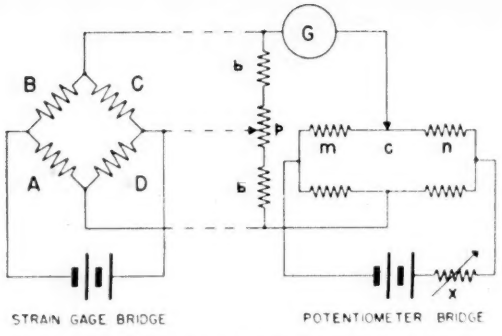


FIG. 9. SIMPLE NULL-METHOD strain-indicating circuit.

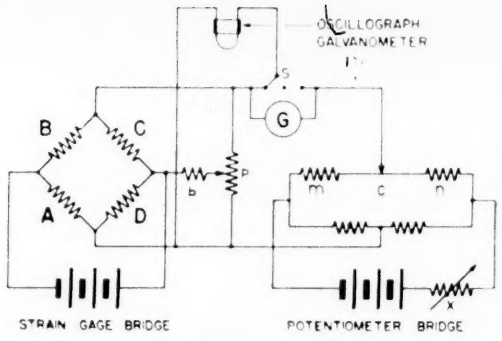


FIG. 10. NULL-METHOD circuit for both strain indicating and recording.

in which S = strain, microincnes per inch; G = gage factor of gages used; n = number of active gages in the bridge; R = bridge arm resistance; r = resistance of microammeter; V = bridge voltage.

For example, assume that 120-ohm strain gages with a gage factor of 2.04 are used with a galvanometer whose resistance is 25 ohms. If we use two active strain gages and a battery voltage of 10 volts, we find by the formula that a strain of 1000 microinches per inch will produce a current of 70.3 microamperes.

A strain of 1000 microinches per inch corresponds to a stress of 30,000 psi in steel, which is probably a maximum figure. As 10 volts is about the maximum voltage that should be applied to the bridge continuously, the maximum output of a 120-ohm strain-gage bridge with 2 active gages is in the order of 70 microamperes.

Null-Type Indicator

Null methods of indicating strain from the output of a strain-gage resistance bridge offer a number of advantages over the simple deflection method described—(1) the indication is not a function of battery voltage, (2) the lead resistance has no effect, and (3) greater accuracy is possible.

A simple, null-method indicator which employs battery excitation of the strain gage bridge is shown in Fig. 9. At left is the standard strain-gage bridge consisting of resistance strain gages or strain gages and fixed resistors; at right is a potentiometer bridge which is excited by a separate battery. The potentiometer bridge includes a slide wire *mn* with a slider *c*, which moves over a long scale calibrated directly in strain. When the slider is at the center of the wire, the bridge is balanced and its output is zero. The balancing or zeroing control for the strain gage bridge is identical to Fig. 8.

In operation, the slider *c* is set at the center or a 0, and the galvanometer G is adjusted to zero by means of the balancing control *p*. After the load is applied, the galvanometer is brought back to zero by the potentiometer slider *c*, after which the strain is read directly on the slider scale.

The method illustrated in Fig. 9 requires two batteries and the potentiometer bridge must be calibrated by adjusting the rheostat X before strain measurements are made. To accomplish this calibration, the voltage across the slide wire *mn* is balanced against a voltage derived from the strain-gage battery by a fixed voltage divider, using the galvanometer G to indicate balance. The circuits required to perform this balance are omitted in Fig. 9 for simplicity.

In the circuit shown in Fig. 9, ac can be employed to excite the bridges, with each bridge excited by a separate winding on a single transformer. The galvanometer G then can be replaced by an a-c amplifier driving a rugged indicating instrument. This system provides a rugged, sensitive and fast balance indication, and the potentiometer bridge can be calibrated permanently at the factory. However, the use of ac requires two balancing controls for the strain-gage bridge, one for resistance and one for capacitance.

An advantage of the battery-excited potentiometer bridge arrangement shown in Fig. 9 is that it can be used in dynamic strain *recording* as well as for static strain indication. This application is illustrated in Fig. 10. Note that when the switch S is in the central position, the circuit is identical to Fig. 9, and the potentiometer bridge can be used for indicating static strain.

When the switch S is thrown to the left, the oscillograph galvanometer is connected directly across the strain-gage bridge as shown in Fig. 8, and strain recording is possible by means of the simple deflection method previously discussed.

When the switch is thrown to the right, the oscillograph galvanometer is connected across the potentiometer bridge to permit calibration of the oscillograph directly in strain. The potentiometer slider then can be moved to any desired strain values, and the corresponding oscillograph deflections noted. This application requires, of course, that the potentiometer bridge resistance be the same as the strain-gage bridge resistance.

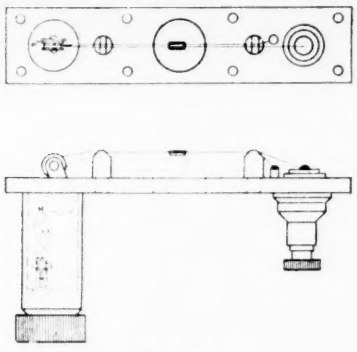


FIG. 11. BIFILAR-TYPE galvanometer.

Dynamic Strain Requires Recorders

Most studies of dynamic strain require recording of strain-time curves, and the recording instrument must be able to accurately follow and record the instantaneous values of strain. Dynamic strain-recording equipment must usually be responsive to static strain also because dynamic strain contains static or low-frequency components.

Peak values of dynamic strain from impacts and explosions can be measured directly without recording, if the wave shape is not required.

Temperature compensation in dynamic measurements is often unimportant—unless a static component is also being measured over a period of time. Balancing circuits and controls also are required to balance the strain-gage bridge if it is desired to record a static component.

An oscillograph or recorder is required to produce the record of strain vs time. Oscillograph galvanometers are available which have a sensitivity great enough to be operated directly from the strain gages without amplifiers, although such galvanometers do not have a frequency response greater than about 300 cycles per second. Amplifiers are required to record strains of higher frequency, or to record low values of strain even at low frequency.

Calibrating equipment also is required to provide convenient and accurate over-all calibration of the system so that the deflection on the oscillogram can be calibrated in terms of strain. The power supply, amplifier, balancing, and calibrating equipment usually is included in an accessory unit called a *strain-gage control unit*.

Galvanometers

Electromagnetic oscillographs are usually of the mirror type (Fig. 11) in which a small mirror is rotated in proportion to the electric current that is to be recorded. As the mirror and its driving element are small, the assembly can be made to respond to frequencies up to about 5000 cycles per second. For higher frequencies cathode-ray-tube recorders must be used.

TABLE 1—CHARACTERISTICS OF TYPICAL BIFILAR GALVANOMETERS

Natural Frequency, cps	Sensitivity, millimeters deflection (at 1 meter) per milliampere current
20,000	0.07
10,000	0.15
5,000	1.4
3,000	9.3
2,000	26
900	134

TABLE 2—CHARACTERISTICS OF TYPICAL COIL-TYPE GALVANOMETERS

Natural Frequency	Sensitivity*	Resistance	Damping Resistance
5000	1.5	30 ohms	
2500	2.5	10	
1000	30	30	
250	880	64	120 ohms
166	5,600	75	350
100	7,500	57	350
35	20,000	26	350

*MM deflection (at 1 meter) per ma

The frequency response of an oscillograph galvanometer is determined by its natural frequency and by its damping characteristics. The sensitivity of a galvanometer is inversely proportional to the *square* of its natural frequency. Because of this relationship, high-frequency galvanometers have a relatively low sensitivity, and galvanometers which are sensitive enough to be driven directly from strain gages without amplifiers are relatively low in frequency response (see Tables 1 and 2).

Bifilar Galvanometers

The bifilar oscillograph galvanometer (Fig. 11) is the simplest mirror-type galvanometer that has been developed. It is capable of high frequency response because the moving element consists of a low-inertia single loop of metallic ribbon or wire stretched tightly between the poles of a magnet, with a small mirror cemented to the center of the loop. This element is characterized by large over-current capacity, extreme resistance to shock and vibration, low resistance, and high frequency possibilities. Fluid damping is employed. Elements with natural frequency to 20,000 cps are available, with a sensitivity of 0.07 millimeter deflection (at 1 meter) per milliampere. Galvanometers of lower frequency have greater sensitivity, as shown in Table 1.

Coil-type Galvanometers

Fig. 12 shows a typical coil-type (D'Arsonval-type) galvanometer. As shown in Table 2, these have lower natural frequency but greater sensitivity. Galvanometers which respond to higher frequency are too insensitive to be driven directly by the resistance strain gages, and require amplification. When amplifiers are not used, high-sensitivity galvanometers must be employed because of the low output level of the strain-gage bridge. The formula for galvanometer current in terms of strain, galvanometer and strain-gage

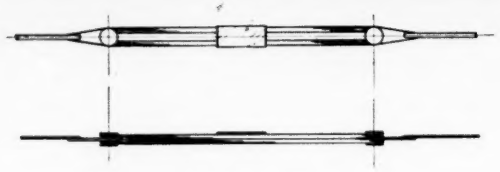


FIG. 12. COIL-TYPE galvanometer.

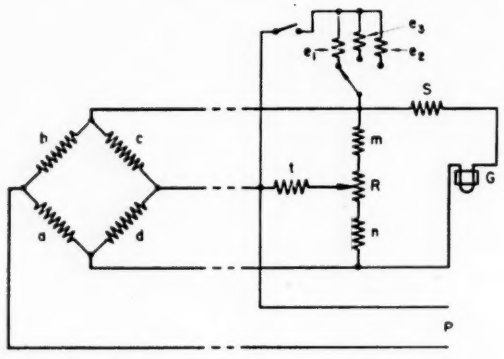


FIG. 13. STRAIN-GAGE circuit without amplifier. Note that bridge-balance and calibration controls are at one end of a 4-conductor line to bridge.

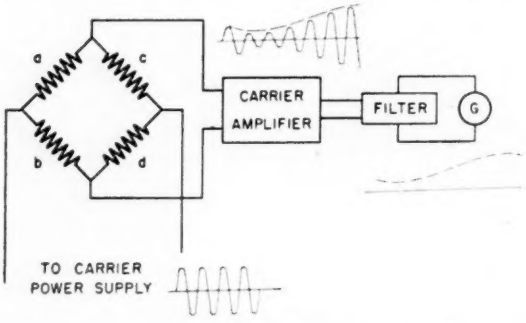


FIG. 14. A-C EXCITED strain-gage circuit with carrier amplifier.

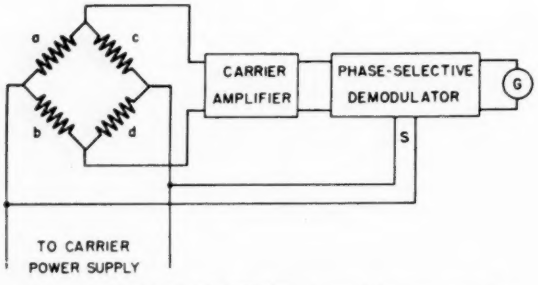


FIG. 15. PHASE-SENSITIVE demodulation permits circuit to distinguish between tension and compression.

TABLE 3—SENSITIVITY OF CARRIER-TYPE CIRCUITS

Galvanometer	Frequency Range (cps)	Maximum Magnification	Sensitivity*
Type OA-2 Group 19	0-250	100,000	2.500
Type OA-2 Group 23	0-500	33,000	.840
Type OC-2 Group 23	0-500	46,400	1.180

*Expressed in millimeters deflection (at 1 meter) per unit strain (1 microinch per inch)

resistances, bridge voltage, and gage factor shows that in the usual cases of strain determination the galvanometer current does not exceed about 70 microamperes. Unfortunately a galvanometer which will provide a practical deflection with 70 microamperes will have a frequency response not greater than 200 to 300 cycles per second. Fig. 13 shows a circuit without amplification.

Strain Recording Using Amplifiers

The disadvantage of having to use amplifiers (Fig. 14) is usually compensated by the higher stability of the high-frequency galvanometers that can be used, and by the fact that such galvanometers are unaffected by heavy vibration and shock.

Although Fig. 14 shows a carrier amplifier, several types of amplifiers can be used, the choice depending on the frequency requirements and the indicator.

If direct current is supplied to the bridge, the output of the bridge will be instantaneously proportional to strain for either static or dynamic strain. However, the direct-coupled amplifier is complicated and costly, and is difficult to adjust and to maintain in balance. Further, stability over long periods of time is difficult to maintain.

Direct-coupled amplifiers are used when a wide frequency range is required, but for the usual problems in strain recording, a-c amplifiers are favored because (1) they can be made much smaller in size and less costly, (2) they do not require accurate balancing of voltages, and (3) their zero is stable. Even though an a-c amplifier will not respond to static strain, it can be given a low-frequency limit as low as 1 or 2 cps.

The Carrier System

Most strain investigations require the measurement of static as well as dynamic strain and the *carrier amplifier*, which combines the advantages of direct-coupled and capacitance-coupled amplifiers, meets this need.

With this system, the strain gage is excited by an a-c carrier voltage that is at least 5 times as high in frequency as the highest strain frequency that it is desired to measure. The bridge output is ac, even though the system is responsive to zero-frequency signals. The filter shown in Fig. 14 causes the galvanometer to follow the *envelope* of the carrier-type signal. This system has the disadvantage that it is not phase sensitive—that is, it will not distinguish between tension and compression. This disadvantage is overcome by using a *phase-sensitive demodulator*, as in Fig. 15.

Total System Sensitivity

As mentioned previously, the power supply for the strain-gage bridge, the balancing circuits, and the calibration circuits are usually included in a multichannel unit called a strain-gage control unit.

Table 3 shows sensitivities and magnifications of typical complete strain-gage systems using bifilar galvanometers, four active gages with gage factor of 2.06, and a "Type MRC-18" strain-gage control unit (which uses a carrier frequency of 5000 cps).

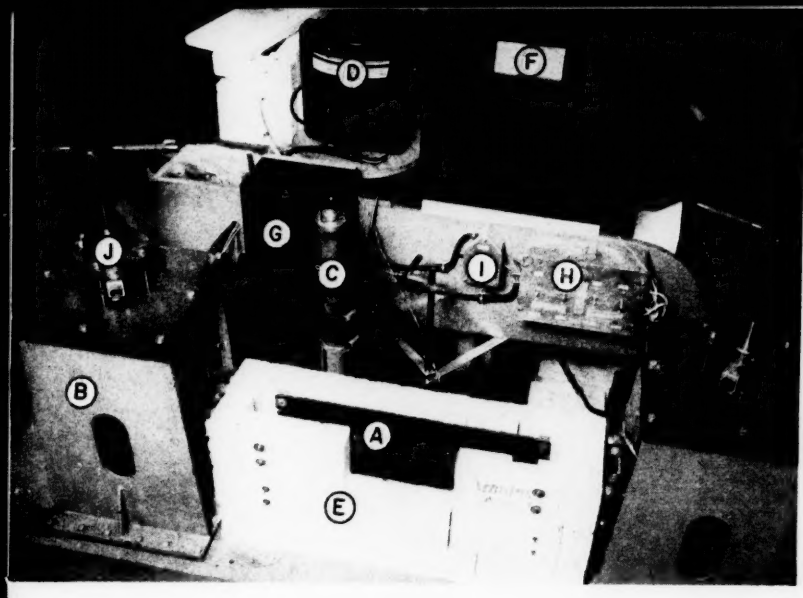


FIG. 1. LABORATORY SETUP by which gage factor is determined for high-temperature experimental resistance gages. (Official photograph, U. S. Navy)

A. Aminco optical strain gage developed for ASL
B. Loading fixture designed by ASL
C. Aminco auto-collimator
D. Wheelco temperature controller
E. ASL strip heater furnace
F. Minneapolis-Honeywell self-balancing microvoltmeter
G. Magnetic amplifier
H. Strip heater control panel
I. Controller selector box
J. Loading screws

Optical Strain-Gage Standard

OPTICAL TECHNIQUES for measuring the stretch of a test bar are used in a laboratory-standard strain gage (Fig. 1) at the Aeronautical Structures Laboratory, Naval Air Material Center. The standard is used in developing and calibrating high-temperature (1000°F) resistance strain gages.

The "optical strain gage" uses extensometers to measure the stretch of a bar by optical means (Figs. 2 and 3). An auto-collimator directs a beam on a prism in the extensometer. The extensometer is attached to the bar in such a way that any elongation of the bar causes the prism to pivot. The amount of elongation is detected by the auto-collimator.

Experimental types of resistance strain gages using heat-resistant alloys are applied to the test bar between two extensometers (D in Fig. 2). When the ambient temperature is at the desired point (up to 1,000°F), equal bending forces are applied from each end of the bar as determined by the strain readings from two auto-collimators. This value is compared with the resistance changes shown simultaneously by the experimental resistance gages.

The optical gage determines strains within ± 4 microinches per inch. The loading fixture (B in Fig. 1) was designed by ASL for applying strain within ± 2 microinches.

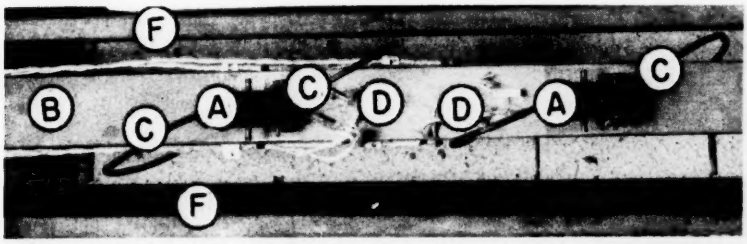


FIG. 2. TWO OPTICAL STRAIN GAGES developed for the ASL by American Instrument Company are mounted with constant tension clamps to a test bar. Between these gages are mounted two experimental high-temperature resistance gages. (Official photograph, U. S. Navy)

A. Aminco high-temperature optical strain gage
B. Test member
C. ASL constant-tension springs
D. High-temperature Instrument Engineering Corporation resistance strain gage made with experimental alloy
E. Armstrong fire brick oven, designed by the ASL
F. Strip heaters

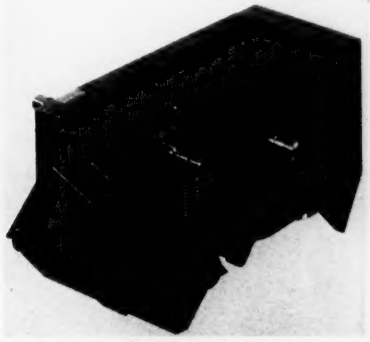


FIG. 3. AMINCO-TUCKERMAN extensometer measures strains within ±4 microinches per inch by optical means.

Sensitivity Ratings

PETER K. STEIN
Stein Engineering Services

TABLE 1—TERMINOLOGY

S = Strain in the test specimen to which the strain gage is bonded. Equals $\Delta L/L$ by definition.

G = Gage factor of the strain gage. Equals $\frac{\Delta R/R}{\Delta L/L}$ by definition.

s = Sensitivity. The various subscripts refer to particular sensitivities as follows:

s_1 = sensitivity rating in terms of unit resistance change (equation 1).

s_2 = sensitivity rating in terms of strain (equation 4).

s_3 = sensitivity rating in terms of bridge output (equation 9).

s_4 = sensitivity rating in terms of shunt calibration resistance (equation 14).

s_5 = another sensitivity rating in terms of shunt calibration resistance (equation 17).

$\frac{\Delta R}{R}$ = Percent or unit resistance change in one arm of the transducer. Subscript t refers to an equivalent total percent resistance change for the entire bridge as defined by equation (2).

Q = Unit of physical quantity applied to the member, such as pressure, force, torque, acceleration, etc.

ΔE = Incremental strain-gage bridge output.

V = Bridge supply voltage.

R_g = Nominal strain-gage resistance of one arm of strain-gage bridge.

R_c = Calibration resistance inserted in parallel across one of the bridge arms.

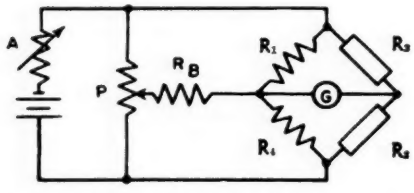


FIG. 1. STRAIN GAGES ARE USUALLY used in a Wheatstone-bridge circuit in which one or more of the arms can be strain gages.

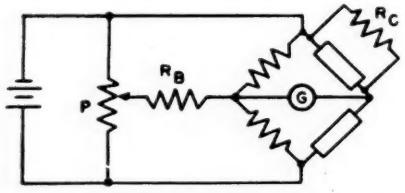


FIG. 2. A CALIBRATION RESISTANCE (R_c) can be placed across one strain gage to calibrate and check the entire strain-measuring system.

FIG. 3. BALDWIN STRAIN INDICATOR can be used to obtain sensitivity rating based on strain.

TRANSDUCERS based on electric-resistance strain-gage principles can have their calibration sensitivity expressed in a variety of ways—and at least four methods are in general use. The many commercially available measuring and recording instruments also use a number of different calibration methods. Frequently it is desirable to have available simple conversion relationships between these various methods of expressing strain-gage sensitivity.

Each of the sensitivity rating methods described in Table 1 has its own applications, and it is important to be able to switch from one rating to another.

The rating based on *unit resistance change*, for example, permits the approximate determination of the total range of a transducer if this is not known. For the type of wire ordinarily used in bonded or unbonded strain gages, a resistance change of 0.005% in each arm is a good rule-of-thumb maximum. Thus, for a four-arm transducer, about 20,000 micro-ohms per ohm is a probable maximum. For linearity, this maximum figure is more frequently reduced to between 10,000 and 15,000 micro-ohms per ohm total resistance change.

If the transducer is of the bonded variety, the rating based on *strain* will permit an approximate computation of the stresses in the member to which the gage is bonded and, if the material is known, a maximum range can be computed based on the structural strength of the transducer. Also, this type of rating is one of the easiest to obtain with a high degree of accuracy because a static calibration of indicated strain *vs* applied physical quantity can be carried out with an instrument such as a Baldwin Strain Indicator (Fig. 3). This instrument is direct reading in strain and exhibits an accuracy of 5 microinches per inch with a range of over 60,000 microinches per inch. It is a reference-bridge null-balance system and capable of accurate calibration work. Based on the sensitivity thus obtained, other sensitivities can be computed as will be demonstrated; they are not obtainable directly.

Strain gages are usually used in a bridge circuit

for Strain Gages

The gage factor (G) of a resistance strain gage is unit resistance-change/unit strain. However, the sensitivity of a strain-gage-based transducer often is expressed in four other ways, such as in terms of bridge output or of a calibration resistance. This article rationalizes the four major ways of expressing the sensitivity of strain-gage-based transducers of all types, bonded and unbonded.

(Fig. 1). The rating based on *bridge output* is most frequently encountered in those instances where the transducer output is to be fed into a voltage-sensitive recording device (or a galvanometer-type recorder). This rating is usually specified as *open-circuit* output voltage per bridge supply voltage, per unit applied physical quantity. This type of calibration can be difficult because accurate, known, supply voltages must be available, and a sensitive and linear high-impedance voltmeter is necessary. A transducer with this type of rating often is used with an instrument which operates on a null-balance principle; in this event a conversion must be made to one of the other sensitivity ratings.

For rapid checks both in the field and in the laboratory there is no better method than the *calibration resistance* method (Fig. 2), wherein artificial resistance changes create bridge outputs which permit checking an entire strain-measuring system. Transducers hardly ever come with a rating such as this, and it is important to be able to compute the necessary resistance values.

Frequently several resistances representing different simulated transducer-loading conditions are applied to one arm of the transducer bridge prior to any measurement or recording. The several points thus obtained permit a rapid check of the linearity of the electric and electronic components between the transducer and the readout device. The calibration resistance can be connected and disconnected across the transducer arm by means of a chopper at any desired repetition rate, thus giving rise to a square-wave of equivalent transducer loads. This chopper system is one of the few methods which permit calibration of a system whose frequency responses does not extend to zero (dc), and which can be applied conveniently in the field.

Rating Based on Unit Resistance Change

Perhaps the most basic of all sensitivity ratings, this method expresses the transducer sensitivity as:

$$s_1 = \frac{(\Delta R/R)_t}{Q} \qquad (1)$$

Usually s_1 is expressed in micro-ohms per ohm resistance-change per unit of applied physical quantity (Q). Here Q can be expressed in units of pressure, acceleration, etc.

A strain-gage usually contains more than one active gage element. Hence a total equivalent $(\Delta R/R)_t$ must be defined for the entire gage. If the subscripts 1, 2, 3, and 4 apply to the four arms of the Wheatstone Bridge in Fig. 1, then:

$$\left(\frac{\Delta R}{R}\right)_t = \frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \qquad (2)$$

Equation (2) expresses the total equivalent $(\Delta R/R)_t$ for the bridge because the strain-induced voltage output from the bridge (Fig. 1) is directly proportional to this algebraic combination of the unit resistance changes in each arm*.

By definition, strain (S) in test member is:

$$S = \frac{\Delta L}{L} = \left(\frac{\Delta R}{R}\right)\left(\frac{1}{G}\right)$$

$$\frac{\Delta R}{R} = SG \qquad (3)$$

The rating based on the $\Delta R/R$ produced by a unit of Q (equation 1), although the most basic, is not always the most applicable rating method.

Rating Based on Strain

Another method of expressing gage sensitivity is:

$$s_2 = S_t/Q \qquad (4)$$

This is expressed usually in microinches-per-inch strain per unit of applied physical quantity. Again, a total equivalent strain must be defined where multiple-gage bridges are used to increase sensitivity. As in equation (2) a total equivalent strain can be defined as follows:

$$S_t = S_1 - S_2 + S_3 - S_4 \qquad (5)$$

From equations (2), (3) and (5):

$$(\Delta R/R)_t = S_1G_1 - S_2G_2 + S_3G_3 - S_4G_4 \qquad (6)$$

This defines a total equivalent gage factor G_t:

$$(\Delta R/R)_t = S_tG_t \qquad (7)$$

from which:

$$G_t = \frac{S_1G_1 - S_2G_2 + S_3G_3 - S_4G_4}{S_1 - S_2 + S_3 - S_4} \qquad (8)$$

*W. M. Murray and P. K. Stein, *Strain Gage Techniques*, 1957 edition, 2 volumes, available from Society for Experimental Stress Analysis.

Thus if those arms of the bridge containing gages have equal gage factors (G), the total equivalent gage factor equals that common value. That is, $G_t = G$.

Rating Based on Bridge Output

The sensitivity can be expressed also in terms of the voltage output (ΔE) from a transducer bridge that is excited by a voltage V:

$$s_3 = \frac{(\Delta E/V)}{Q} \qquad (9)$$

This s_3 is used frequently and expressed usually in millivolts bridge output per volt supply voltage per unit of applied physical quantity.

The relationship between output voltage and percent resistance change in the bridge arms for an initially-balanced equal-arm bridge is:

$$\Delta E/V = (1/4)(\Delta R_g/R)_t = (1/4)(S_t G_t) \qquad (10)$$

Relationships between s_1, s_2, and s_3 can be established by equation (10), as in Table 2.

Rating Based on Shunt Calibration Resistance

Frequently system calibration can be achieved by introducing resistance change in one of the arms of the bridge by shunting a calibration resistance R_c across that arm* (Fig. 2).

The resistance change thus produced is:

$$\Delta R_g = R_g - \frac{R_c R_g}{R_c + R_g} = \frac{R_g^2}{R_c + R_g} \qquad (11)$$

A unit resistance change $\Delta R_g/R_g$ has been created:

$$\frac{\Delta R_g}{R_g} = \frac{R_g}{R_g + R_c} \qquad (12)$$

This artificially simulated "strain" creates a bridge output equivalent to a certain amount of Q applied to the transducer. From equations (9), (10), and (12):

$$\frac{\Delta E}{V} = (1/4)\left(\frac{1}{1 + (R_c/R_g)}\right) = s_3 Q \qquad (13)$$

Note that this is the same as given in equation (9). A sensitivity s_4 can be defined in terms of R_c:

$$s_4 = R_c/R_g \qquad (14)$$

Note: s_4 depends on the value of Q used to evaluate it: hence it is a nonlinear expression in terms of Q.

$$s_4 = R_c/R_g = \frac{1}{4 s_3 Q} - 1 \qquad (15)$$

A shunt resistance can only *decrease* the equivalent resistance in *one* arm of the transducer bridge, thus:

$$4 s_3 Q < 1 \qquad (16)$$

Equation (16) must be fulfilled in order to obtain real positive values for R_c.

A fifth sensitivity s_5 can be defined in terms of R_c:

$$s_5 = \left(\frac{R_g}{R_g + R_c}\right)\left(\frac{1}{Q}\right) \qquad (17)$$

Note: s_5 also is independent of the value of Q used to determine it: a linear function in Q has again been obtained.

It is fortunate that in most practical cases:

$$R_c >> R_g \qquad (18)$$

Thus:

$$\frac{R_g}{R_g + R_c} \approx \frac{R_g}{R_c}$$

Hence it is possible to define:

$$s_5' = R_g/R_c Q \qquad (19)$$

This is a simpler expression than s_5 in equation (17) and equals s_1 if condition (18) is fulfilled.*

Sample Problems

A strain-gage load cell is calibrated for applied load *vs* total apparent strain on a Baldwin Type L Strain Indicator. A sensitivity s_2 in microinches per inch per pound of applied load (s_2) is given. Determine the sensitivity rating in terms of millivolts volt-pound (s_3) and compute the shunt resistance necessary to simulate a 1000-lb load.

Data: Gage resistance: $R_g = 120$ ohms
Gage factor: $G_t = 2.00$

From Table 2 the relationship between the two sensitivities is:

$$s_3 = s_2 G_t/4$$

It is now necessary to adjust to compatible units. For example, 1 microinch per inch equals 10^{-6} inch per inch (in compatible units). Also units of volts/volt-lb are converted to the desired mv/v-lb by a factor of 10^3.

$$s_3 = s_2 \times 10^{-6} \times 1/4 \times G_t \times 10^3 = s_2\ 2000 \text{ mv/v-lb}.$$

From Table 1:

$$s_4 = R_c/R_g = \frac{1}{s_2 Q G_t} - 1$$

$$\frac{10^6}{2 s_2 10^3} - 1$$

$$\frac{500}{s_2} - 1$$

*The shunt-resistance calibration method permits checking of a single bridge arm. However, it has disadvantages. There is also a "bridge-series-resistance" calibration method which creates equivalent voltage output across the bridge terminals. (see Chaper XIX of *Strain Gage Techniques*, referenced previously).

*Some transducers are equipped with resistors in series with the bridge supply voltage, acting either as compensators for temperature-induced variations in the modulus of elasticity of the structure to which the gages are attached, or as range control resistors. When these resistors form an integral part of the transducer, i.e., when the four bridge corners are not directly accessible externally, the above equations will be in error unless the resistances are divided equally on either side of the supply voltage. For a complete discussion of the problem see *Strain Gage Techniques*, referenced previously.

And the shunt resistance (in ohms) across one arm of the bridge is:

$$R_c = (60{,}000/s_g) - 1$$

The load cell thus can be accurately calibrated statically with a null-balance system such as the Baldwin Indicator, and the results can be translated into calibration factors for unbalance measuring systems which may be used dynamically, where direct calibration is perhaps impossible. Similarly, suitable resistances can be selected based on the static null-balance calibration such that in-the-field rapid calibration checks can be performed by periodic insertion of the computed shunt resistance across one arm of the bridge.

Sample Problem 2

The Model 150-1100 Carrier Amplifier plug-in unit to the 150-series Sanborn recorder presents a more complex problem in sensitivity-rating translation. It possesses an *instrument factor* (IF) dial which is set to the sensitivity value of the transducer used, expressed in millivolts/volt rated load Q, or s_3.

Depression of the "Calibration" button results in a recorder-needle deflection equivalent to 2% of the unit Q used in setting the instrument factor dial. Strain gages do not have any specific *rated load* (recommended unit of Q), such as expected from other types of transducers, so a conversion is desired to adapt the strain gage to the instrument. Furthermore, a zero-suppression (n) dial on the instrument panel can be set at any value from 0 to 1.00, thus supressing the first $100n$% of the rated load Q used in computing the instrument-factor setting. A conversion of the zero-suppression dial reading n into terms of strain also is desired.

Let S_t be the arbitrary "rated strain" for which the IF setting will be:

$$IF = \Delta E/V = 1000 S_t/4$$

This is from equation (10). The factor of 1000 is necessary to convert the mixed units of *millivolts per volt* and *microinches per inch* into their non-dimensional companions *volts/volt* and *inches/inch*.

But the suppressed strain S_s is:

$$S_s = nS_t$$
$$S_s = 4000n(IF)/G$$

Take $n = 0.02$ as special case and solve for the calibration strain:

$$S_{cal} = 80(IF)/G \text{ microinches/inch}$$

Thus the Sanborn instrument factor and the strain-gage factor have little in common except that it is their ratio which determines the equivalent strain introduced into the recorder system by the calibration button. Thus, if a strain gage of 2.00 gage-factor is used, an equivalent strain of 40 microinches per inch will be introduced by the calibration button when the Sanborn instrument-factor dial is set at 1.00. If the dial is set at 2.00, the equivalent strain will be 80 microinches per inch, and so on. Similar arguments hold for the zero-suppression dial, which now can be interpreted indirectly in terms of microinches per inch, instead of percent of rated load suppressed.

TABLE 2—RELATIONSHIP BETWEEN VARIOUS SENSITIVITY RATINGS:

Sensitivity Rating	Expressed in Terms of s_1 or s'_3*	s_2	s_3**	s_4
s_1	$\frac{(\Delta R/R)_t}{Q}$	$s_2 G_t$	$4s_3$	$\frac{1}{Q(1+s_4)}$
s_2	s_1/G_t	S_t/Q	$4s_3 G_t$	$\frac{1}{QG_t(1+s_4)}$
s_3	$s_1/4$	$s_2 G_t/4$	$\Delta E/V/Q$	$\frac{1}{4Q(1+s_4)}$
s_4	$\frac{1}{s_1 Q} - 1$	$\frac{1}{s_2 Q G_t} - 1$	$\frac{1}{4s_3 Q} - 1$	$\frac{R_c}{R_g}$

*$s_3 = s_5$ and also approximately equals s'_3 (Defined as $R_g/R_c/Q$) when $R_c >> R_g$ with an error of less than 1% for $R_c > 100\ R_g$.
**Defined for an initially-balanced equal-arm bridge.

Sample Problem 3

A Statham type P6-3D-350 differential-pressure transducer has the following characteristics:

$s_3 = 0.921$ millivolt/volt/psid

$R_g = 345.3$ ohms for each of the four arms.

Determine the sensitivity in terms of the total micro-ohms per ohm per psid, and compute the shunt resistance required to produce a simulated bridge output of 1-psi differential pressure. From Table 2:

$$s_1 = (\Delta R/R_1)/Q = 4s_3$$
$$= 4 \times 0.921 \times 1000$$
$$= 3684 \text{ micro-ohms/ohm/psid}$$

From Table 2:

$$s_4 = R_c/R_g = (1/4s_3 Q) - 1$$

as $Q = 1$ psid:

$$s_4 = \frac{10^6}{4 \times 0.921 \times 1000 \times 1} - 1$$
$$= 272$$

Therefore

$$R_c = 272 \times 345.3 = 93{,}840 \text{ ohms}$$

Thus 93,840 ohms are required to simulate 1-psi differential pressure.

Sample Problem 4

In the Sanborn Model-60 strain-gage plug-in unit, calibration is accomplished by shunting a 1-megohm resistor across one of the bridge arms. Find the equivalent differential pressure signal thus produced from the Statham transducer described previously.

From equation (15):

$$Q = \frac{1}{4s_3(1 + R_c/R_g)}$$
$$= \frac{1}{(4)(0.921)(10^{-3})(1 + 10^6/345.3)}$$
$$= 0.0938 \text{ psi differential pressure produced by } 10^6 \text{ ohms shunted across arm of the bridge}$$

High-Temperature Strain Gages

LOUIS HERCZEG and **PAUL BECKMAN,** High Temperature Instruments Corp.

NUCLEAR REACTORS, guided missiles and high-speed aircraft require strain measurement at elevated temperature. Work on this problem showed that conventional strain gages are inadequate and led to several major advances in the strain-gage art—(1) small size, (2) built-in thermocouple, (3) metallic screen backing, a new technique.

Size

Until recently, gage lengths ranged from ¾ inch to 2 inches. Gages indicate *average* values of strain over their length and the readings become meaningless where large strain and temperature gradients exist. The first advance was the making of gage lengths of only 1/16".

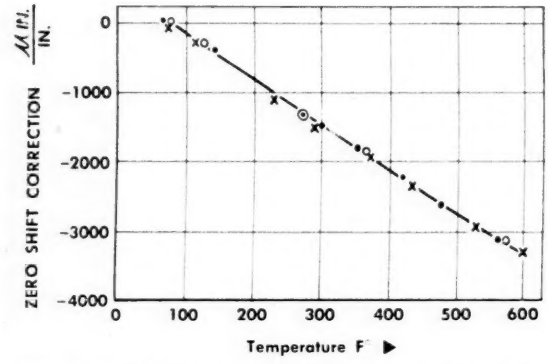


FIG. 1. ZERO SHIFT CORRECTION vs temperature for H-T-600 Static gage, Allen PBX cement, on specimen 302 B steel, zero load, no constraint.

Grid Temperature Determination

A number of gage properties—gage factor, gage resistance and leakage to ground—are functions of temperature. Hence the grid temperature must be known accurately. This led to the development of a combined thermocouple and strain gage—the "thermocouple strain gage."

Stability

A major obstacle to use of strain gages at high-temperature has been instability. The strain-gage resistance should be drift-free. However, the following cause a major part of the drift in a strain-gage installation:

1. *Strain-gage grid material*

Regardless of the number of heating cycles and the heating and cooling rates, there should be only one value of resistance for each temperature. The temperature history of some of the most widely used alloys shows that they do not meet this requirement. An evaluation of alloys found two which have the desired properties—these have been incorporated into two gage types, the H-T-600 Static and the H-T-1200 Static.

2. *Strain-gage cements*

The cement used is as important as the gage itself. There are two widely used cements—the Allen PBX and the Allen P-1.* Preliminary tests show that PBX

*Robert G. Allen Co.

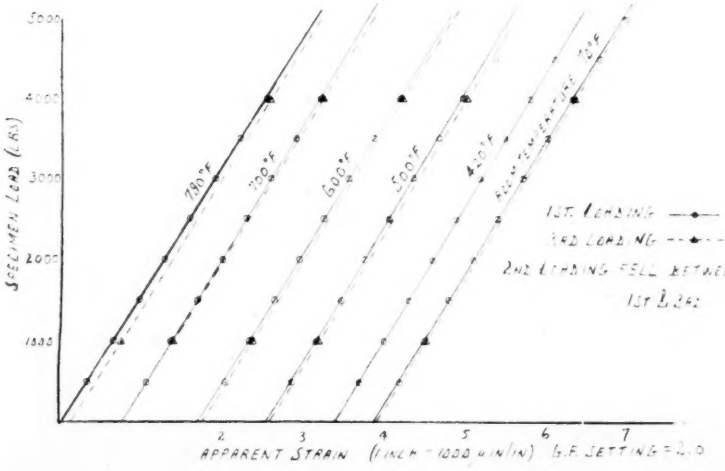


FIG. 2. CURVES of load versus apparent strain at various temperatures. Effect of drift is also apparent.

gives higher values of leakage-to-ground and provides more stable gage installations. A complete evaluation of these cements may lead to further refinements and an "ideal" cement (one that can be cured at room temperature and used to any temperature desired).

3. Curing a strain-gage installation

There is no one set curing methods for all gage types; curing procedures are determined experimentally for each gage type. For example, curing the H-T-1200 Gage at 1250°F for one hour causes it to be drift-free up to 1000°F.

Temperature Corrections

A drift-free gage, together with a thermocouple, will allow the use of calibration charts and equations for accurate determinations of strain at high temperature. Fig. 1 shows a typical calibration chart.

Future Refinements

1. *Temperature Compensation.* By using the proper proportion of alloys in the strain gage, temperature self compensation is possible. This does not reduce the need for a thermocouple because the gage factor is a function of temperature.

2. *Metallic screen backing.* The performance of metallic-screen-backed gages (a new technique of High Temperature Instruments Corp.) looks promising. Such a gage can be cured at any desired temperature before installing it on the member to be tested. It can be mounted on the test member by soldering, welding, brazing, cementing, etc.

Result of Tests at Republic Aviation

An H-T-100 (Karma wire) high temperature strain gage has been the subject of an analysis by Republic Aviation Corporation, resulting in Fig. 2 (linearity), Fig. 3 (correction factors), and Fig. 4 curves.

Fig. 2 shows the linearity of curves of load *versus* apparent strain. The effect of drift is also apparent.

Fig. 3 shows a curve of gage correction factors by which the gage factor at room temperature can be corrected to other temperatures.

Fig. 4 shows the relation of apparent strain to temperature for three H-T-100 gages on stainless steel. One of the gages had its characteristic altered by adjusting the length of the nickel lead in series with the Karma wire of the gage. A more consistent temperature-resistance relationship from gage to gage should be realizable by limiting both curing and test temperatures to definite values. If such consistent characteristics can be realized, then an optimum length of nickel lead would result in a flat characteristic over a wide temperature range.

Acknowledgement

The characteristics of the H-T-100 gage (Figs. 2, 3 and 4) are the result of work by R. L. Makemson, Senior Research Engineer, Republic Aviation Corp., Farmingdale, L. I., N. Y.

Thanks are due to the following for their contribution to the development of these high-temperature gages: (1) Mr. Eugene Cohn, President, Secon Metal Corporation, White Plains, N. Y. for his development work in the platinum base alloys used in the H-T-1200 Static gage. (2) Driver-Harris Corp., Harrison, N. J. (3) Robert G. Allen Co., Mechanicville, N. Y. (4) Dr. D. P. Detwiler, College of Ceramics, Alfred University, Alfred, N Y. (5) Foster-Wheeler Corp., 666 Fifth Avenue, New York, N. Y. (6) Republic Aviation Corp., Farmingdale, Long Island, N. Y.

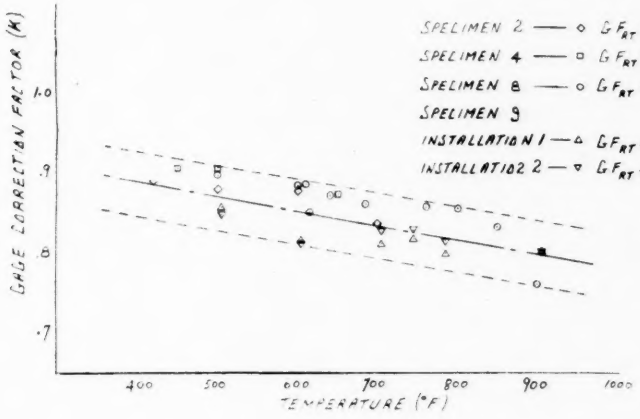


FIG. 3. GAGE CORRECTION factors by which gage factor at room temperature can be corrected to other temperatures.

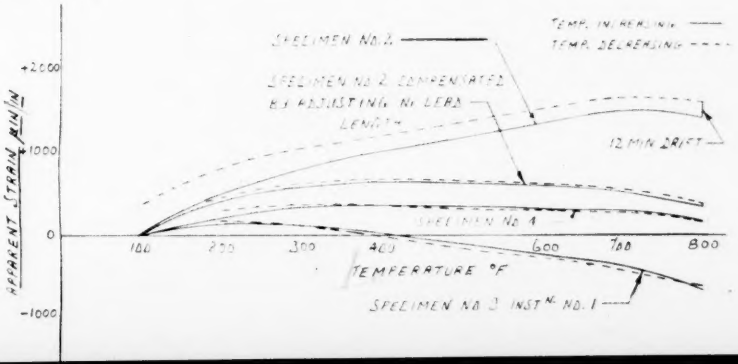


FIG. 4. TEMPERATURE versus apparent strain for three H-T-100 gages on stainless steel.

A Nomogram For Second-Order Systems

LESLIE R. AXELROD
Cook Electric Co.

IN THE December issue of *Instruments and Automation* the characteristic equation of a second-order system was compared with the equation written in terms of two "normalized" quantities (the damping ratio ζ and the undamped natural frequency ω_n). That is:

$$s^2 + \frac{A_1}{A_2}s + \frac{A_0}{A_2} = s^2 + 2\zeta\omega_n s + \omega_n^2$$

A graph was presented which showed how ζ and ω_n would vary as the coefficients A_0, A_1 and A_2 were permitted to assume various values.

A simple, direct approach for finding ζ and ω_n is given here.

$$\zeta = \frac{A_1}{2\sqrt{A_0 A_2}}$$

$$\omega_n = \sqrt{\frac{A_0}{A_2}}$$

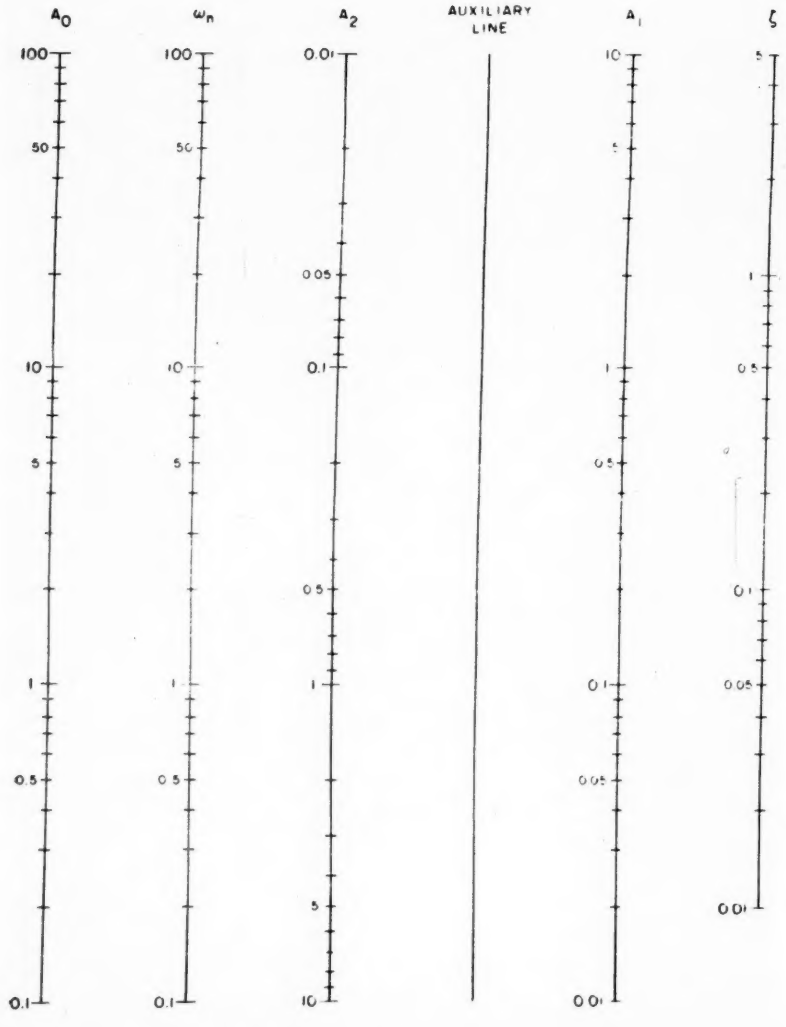
The accompanying nomogram provides a rapid straightforward means for obtaining these quantities as functions of A_0, A_1 and A_2. The method to use is as follows:

1. Draw a line between the values of A_0 and A_2: the point of intersection X of this line on the ω_n axis immediately yields ω_n.

2. Draw a line between the values of A_1 and A_2: mark the point of intersection Y on the auxiliary line.

3. Draw a line between X and Y: its intersection on the ζ axis yields the value of ζ directly.

Although the ranges of A_0, A_1 and A_2 are somewhat limited, use of scale factors will extend the range of the nomogram to any values the A's may assume.



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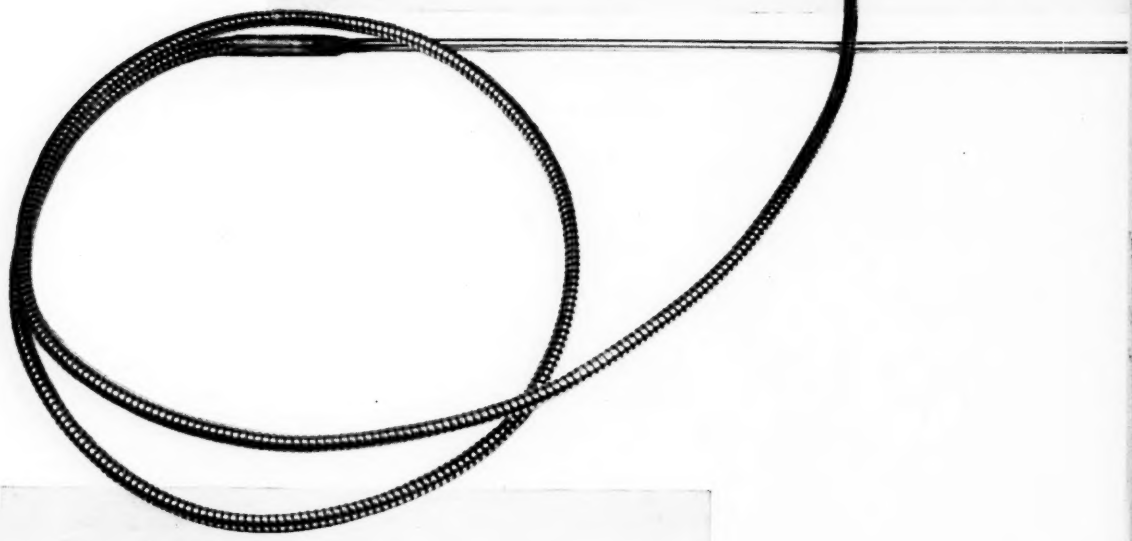

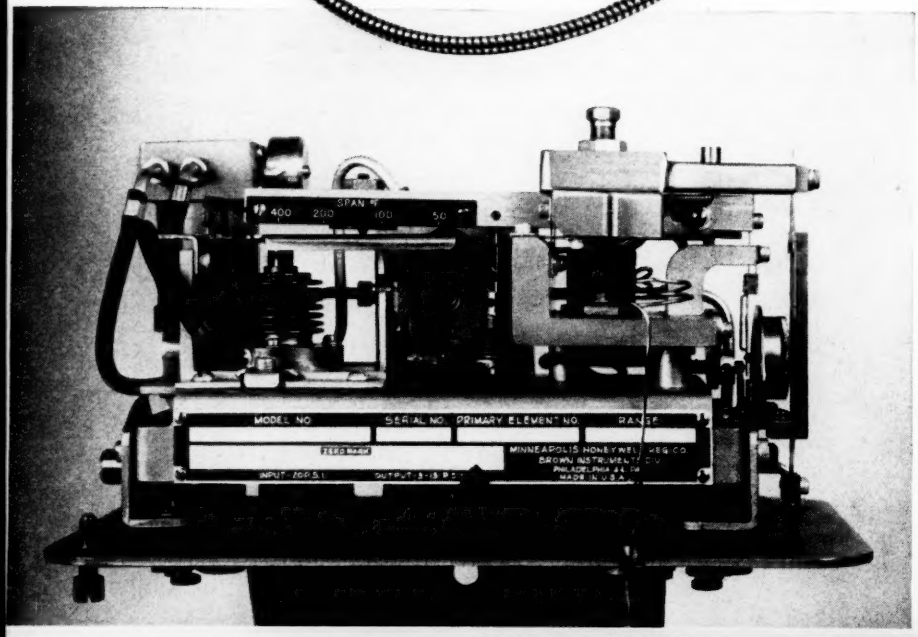

Interior view of the transmitter shows the accessibility of all parts. Span and zero adjustments are easy to make, and no changes of parts are required.

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This method weighs contents of each bunker in multi-bunker structures regardless of load in adjoining bunkers. Gage mounting details are included. Rosette gages compensate for temperature.

W. D. HAMILTON
General Electric Co.

Multi-Bunker Weight Measurements

WHERE SEVERAL BUNKERS or bins are supported by beams common to two bunkers it has been difficult to weigh the contents of one bunker without interference from the connected bunker.

At General Electric Company's Hanford Atomic Products Operation at Richland, Washington, a method has been devised to weigh coal in such a multi-bunker installation (Fig. 1) by using Baldwin SR-4 strain gages.

Weight Measurement Technique

If the contents of one bunker or bin are to be weighed, it is common practice to install load cells in each leg, or to place a strain gage on each of the four supporting members because the compression of all four supporting members is proportional to the weight. All of the gages would be wired in the same leg of the Wheatstone bridge.

When weighing the contents of one bunker in a multi-bunker installation, stress coupling (transmission of the stress present in one unit to another unit through a common member) becomes a serious problem. For example, as bunker A has two supports in common with bunker B, the weight of the contents of bunker A also will compress these two legs.

Vessel Strain Analysis

Numerous tests were conducted at Hanford to locate a point on the bunker shell where the stress of the metal was proportional only to the weight of the contents. Several tests failed because the metal stretched proportionally as coal was added only up to a point where additional coal would compress the metal. This was caused by the weight of the coal acting as the weight on a lever, the pivot point being the reinforcing members. When the coal level was below the reinforcing member, the metal would expand. When the coal level was above this member, the metal above would bend out causing the metal below to bend in, or compress.

Next a point X was located on an "I" beam used to reinforce the side of the bunker (Fig. 2). As coal was added, this beam would bend causing the metal at point X to *stretch*.

The stress transmitted from the adjoining bunkers compressed the metal at point X. To correct for this, two gages were used, one at point X and another at the point Y (Fig. 2). As the beam bends, the metal at point X stretches and the metal at point Y compresses in proportion to the weight of the coal in the bunker. The transmitted stress from the adjoining bunkers compresses both points X and Y equally, causing the same change in their resistances.

The gages were connected so the compression of gage Y and the stretching of gage X were additive while the transmitted stress applied to both gages cancelled out (Fig. 3). As the beam bends, gage X increases in resistance, decreasing the potential at point

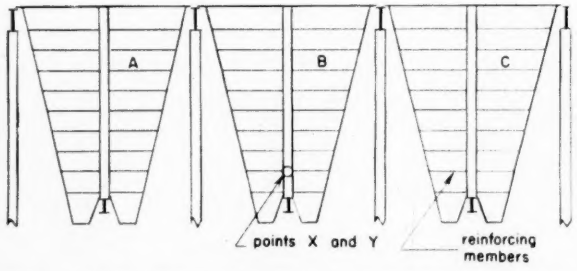


FIG. 1. MULTI-BUNKER INSTALLATION. Supports shared by more than one bunker nullify use of load cells for determining weights of contents of individual bunkers. Horizontal lines are reinforcing members.

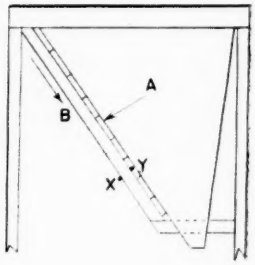


FIG. 2. SIDE VIEW of bunker. X and Y are points on opposite surfaces of I beam supporting sloped surface of bunker. Reinforcing members are between I beam and bunker shell.

N, and gage Y decreases in resistance raising the potential at point M. This produces an electrical output twice the magnitude produced by using one gage. The transmitted stress compresses both gages X and Y, affecting both legs of the bridge equally, and the potential difference between points M and N remains the same. Thus only the weight in one bunker is measured without interference from the weight of the contents in the adjoining bunkers.

Temperature Correction

Most materials expand when heated and the stress produced by temperature change affects the resistance of the strain gage. Although both gages were attached to the same material and are close to each other, one gage was shielded by the reinforcing members while the other gage was exposed to air drafts (Fig. 4). This caused the two gage surfaces to differ in temperature.

Fig. 5 shows how the rosette-type gage corrected for these temperature changes. The metal expands equally in all directions when heated and affects both coils of each gage equally. As both coils increase in resistance an equal amount, the resistance ratio of the active coil (X_1) to the compensating coil (X_2) remains the same. However, the stress produced by bending the beam affects coil X_1 but not X_2. Thus the potential differential between points M and N varies with stress caused by the beam bending, but is independent of temperature.

Installation

The following procedure was adhered to during installation:

1. The surface was sanded clean of paint and rust with a disc-type electric sander.
2. The surface was then hand sanded with 320-grit sandpaper.
3. The area was cleaned with acetone to remove all dirt and oil film.
4. A small drop of "Duco" cement was applied to each side of the A-X-7 strain gage and the strain gage was worked between the fingers to assure penetration of the glue.
5. A small drop of glue was applied to the beam and the gage was pressed to the surface.
6. A small piece of cellophane was place over the gage. Over this a piece of sponge was placed and clamped to the beam with a rubber band to assure that even pressure was applied to the gage throughout the drying process.
7. The gage was allowed to dry for 24 hours.
8. The lead wires were then connected, using care not to break the small gage leads.
9. The area around the strain gages was heated with a heat lamp, and a coating of melted Cerese wax was applied for water-proofing.
10. The complete gage and wax was covered with a small plastic box to prevent any physical damage to the gage. The lead wires were clamped to the beam to prevent the weight of the wire causing a stress on the strain gage.

Power Supply

The results are no more accurate than the power supply; a power supply regulated to within 1% will cause the results to vary within 1%. Numerous power supplies with good regulation are commercially available. An a-c power supply can be used if the recorder will accept an a-c signal.

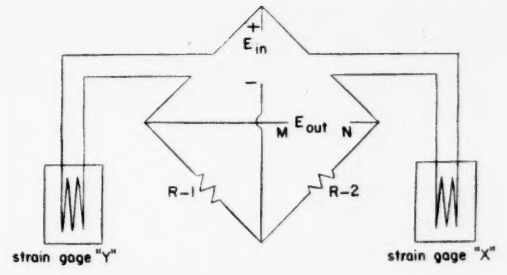


FIG. 3. WHEATSTONE BRIDGE circuit corrected for compression from adjoining bunker.

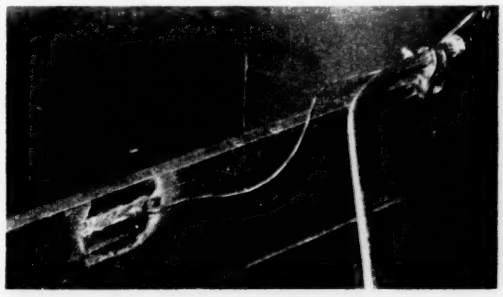


FIG. 4. I BEAM with gage X at left; gage Y is on opposite surface at top right. Reinforcing member can be seen at right.

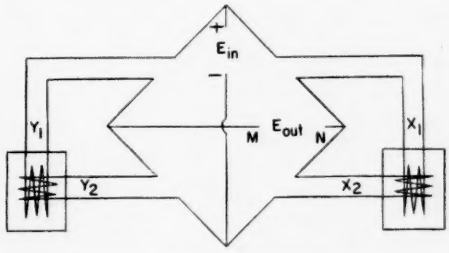
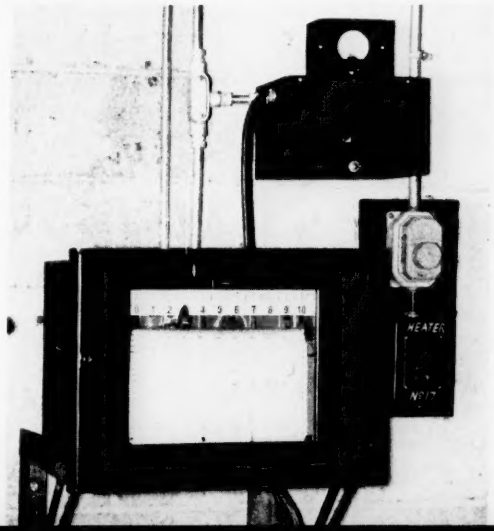


FIG. 5. WHEATSTONE BRIDGE circuit compensated for temperature.

FIG. 6. RECORDER shows weight for one bunker.



PHOTOSTRESS ANALYSIS

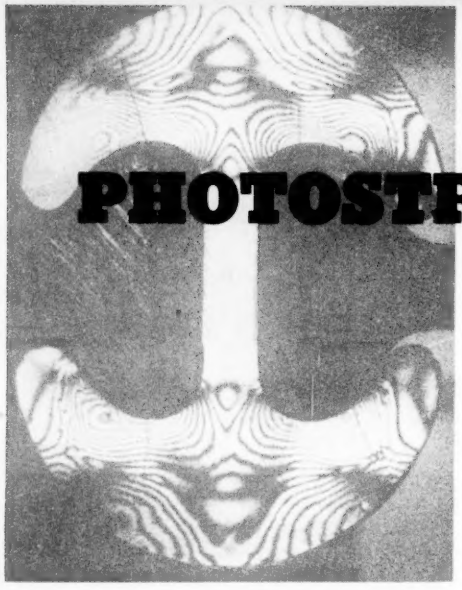


FIG. 1. ISOCHROMATIC pattern on section of sheet piling at 7000-lb load shows lines of equal tension and compression strains.

BRUCE SUTTON

Tatnall Measuring Systems Co.

PHOTOSTRESS is a photoelastic experimental strain-analysis technique in which the actual structure to be analyzed is coated with a special transparent plastic. This plastic is supplied in flat sheets which can be bonded to flat surfaces, and as a liquid which can be brushed on or molded into a contoured sheet for curved surfaces. When a load is applied to the structure thus coated, strains are transmitted to the coating, causing a change in the refractive index of the plastic. This change in refraction index is directly proportional to the strain intensity.

Double Refraction

The plastic material divides the incident light rays into two beams having different speeds. Further, the two beams are plane polarized in planes that are at right angles to each other. The double-refraction is called *birefringence*, and the polarized output beams can be examined by a polariscope.

As the speeds of the two beams coming out of the plastic are different, interference effects are produced, leading to either black or colored lines (depending on whether monochromatic or white light is used in the examination).

PhotoStress differs from conventional photoelastic technique in which a plastic model of the member is made and light transmitted through the model is viewed by polariscope. PhotoStress differs primarily in that the polarized light is reflected from the surface of the part that is coated with the plastic.

Isoclinic Fringes

The black (isoclinic) fringes are the loci of points where the direction of the principal stresses are constant and in the same direction as the axis of the polarized light (Fig. 1). These black fringes are visible when the polarization axes of the instrument's polarizer and analyzer are crossed at 90°. It is easy to plot the two families of isostatics from these isoclinic fringes. (Isostatics are stress trajectories that are lines drawn tangent to the direction of major stress.)

Measurement Technique

The four basic methods of measuring the fringes (or color value) in the plastic, which give the principal strains in the part, are as follows: 1. Identify the color observed, and look up its corresponding strain value on a "color-versus-strain" conversion chart.

2. Find a black line or area and count the number of successive "tint of passage" fringes from this black line. A "tint" of passage" is a sharp line between red and blue. This method permits strain determinations at any point located on such a fringe.

3. Use an optical compensator calibrated in terms of strain. Compensators are used if the number of tints of passage is insufficient, or if stresses are to be determined at a point outside a fringe. An optical compensator artificially produces an isochromatic fringe that represents a known amount of strain and can be compared with the unknown strain at any given point of the birefringent plastic.

4. Convert colors into photoelectric currents and measure these by calibrated photometers.

Advantages

Advantages of the technique include:

1. It is the equivalent of an infinite number of strain-gage rosettes with virtually zero gage length distributed uniformly and continuously over the entire surface of the actual structure. This gives overall strain distribution.

2. Can be applied to any structural material (metals, concrete, wood, glass, rubber, etc.).

3. Permits recording or photographing the stress patterns.

4. Permits both static and dynamic measurements. Dynamic measurements are made by photography, motion-picture camera, photocell recordings or by using a strobe light.

5. Permits determination of magnitude and sign of the two principal strains.

6. Establishes the value of the difference in principal strains and maximum sheer-stress.

7. Can give the directions of principal strains within ±2°. Isostatics or stress trajectories can be plotted.

8. Strain accuracy is 10 microinches per inch for optical readings and can be improved by using photocells.

9. Permits measurements of large strains up to 30,000 or 500,000 microinches per inch (3% or 50%), depending on type of plastic used.

10. Makes possible measurements on surfaces ranging in size from a crystalline grain to any large surface.

11. Permits optical and electrical telemetering; can be used as a transducer; and permits automatic measurements.

Limitations

1. Stresses cannot be measured in areas inaccessible to light. Residual strains can be measured if a component part that has been stressed beyond the elastic limit becomes accessible to light after dismantling.

2. The strain-optical constant K varies for temperatures outside the range of 44° F to 80° F. Corrections can be made for such temperatures.

3. A wide temperature variation during a test may result in a parasitic birefringence caused by the difference in expansion between the workpiece and the plastic. In this event it is necessary to measure the birefringence before and after loading.

4. It provides only surface strains.

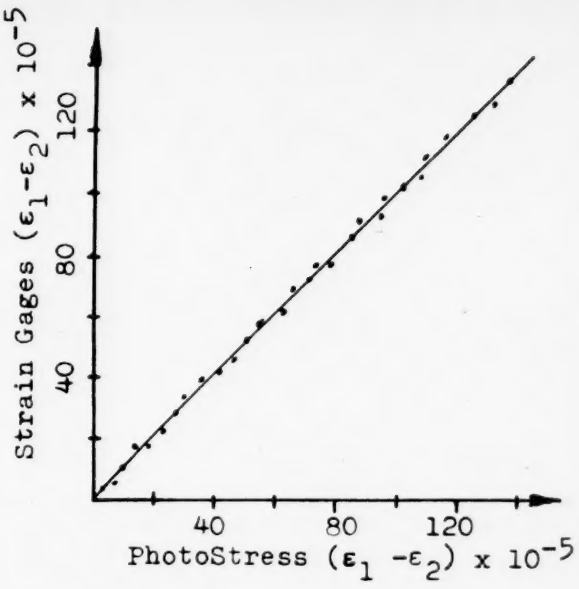


FIG. 2. COMPARISON of PhotoStress results with strain-gage results on a typical member.

A First—And Exclusive—Disclosure

The Odd Rule

GIRARD SCHIVLEY

ANYONE using a rule graduated in 64ths or 100ths knows the difficulty of reading the closely spaced index markers. This "Odd-Rule" technique (Fig. 1) eliminates all scribe marks of *even-numbered values* in the scale, with the exception of the inch-unit marks. Deleting every even-valued scribe mark allows an "opened up" scale without any loss of accuracy. Just how much the scale is opened is shown by the fact that 31 scribe marks are deleted in one inch of 64ths.

This method is practical because there is no reason for retaining the even-numbered values of a two (or four) valued scale.

For example, 2/32" is the same as 1/16", and there is no reason to have the second mark on a scale graduated in 32ths of an inch—*if a scale graduated in 16ths is available.*

Similarly, 2/16" is the same as 1/8th", and there is no reason for any even graduations on a 16ths scale—*if a scale graduated in eighths is available.*

The ODD-RULE is thus a series of scales graduated only in odd graduations, and it is necessary only to select a graduation on the proper scale.

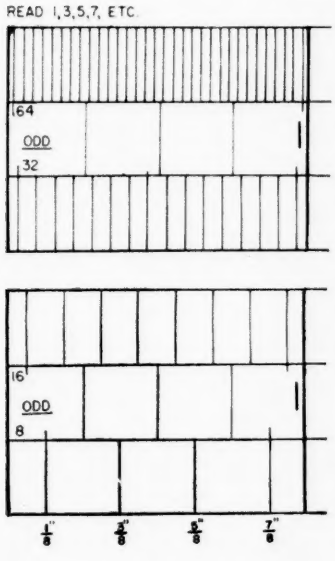


FIG. 1. EXPANDED view of one inch of odd-rule.

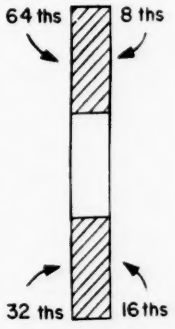


FIG. 2. SIDE view of scale.

Possible Variations

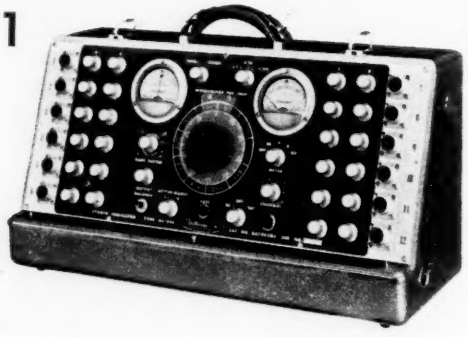
The method of indexing can be used also for rules graduated in hundredths, fiftieths, etc.

The center portion of the rule shown in Fig. 1 can be transparent for ease of measurement.

As the basic advantage of the Odd-Rule is the reduction of the number of index markers, the advantage is greatest for reading the scales graduated in 32ths and 64ths. Hence the rule could also be with a conventional rule graduated in 16ths (which is easy to use) on one side or on the center section of the rule, and the other side graduated in "odd-rules".

The rule also has go—no-go gaging possibilities.

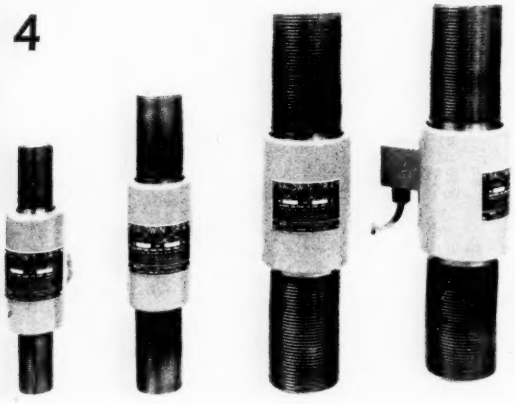
Strain-Gage



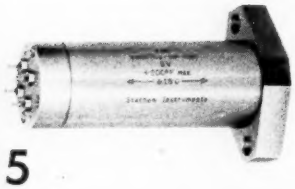
1 **STRAIN INDICATOR** RS-20C of Hathaway Instrument Div., Hamilton Watch Company, is 12-channel, self-powered or line-powered, portable instrument. Bridges are excited by 5000-cps carrier power. Balance is indicated by null indicator. Phase-sensitive discriminator makes direction or deflection depend on direction of unbalance. Gage factor control can be set at any value from 1.70 to 2.30 within ¼%.

2 **BRIDGE AMPLIFIER AND METER** Model BAM-1 of Ellis Associates measures static signals directly on meter, dynamic signals on oscilloscope. Features: scales calibrated to units used; bridge balanced for initial zero; thermoelectric effects cancelled. Frequency response is flat within 5% from dc to 25,000 cps and slowly drops off at higher frequencies. Stability is within 100 microvolts per hour.

3 **B-1 BRIDGE** of Ellis Associates features: power line operation; drives high resistance bridges; regulated dc power on bridge; meter roughly balances bridge and indicates gage current; wide range calibration; low electrical noise pickup; 10-mv output usual; will drive mirror-type galvanometers up to 200-cps response directly.



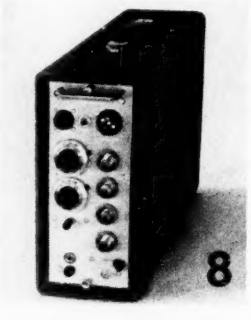
4 **TYPICAL LOAD CELLS** of Baldwin-Lima-Hamilton Corporation use bonded strain gages.



5 **ACCELEROMETER** Model A501TC of Statham Instruments Inc. uses unbonded strain gages. Ranges are ± 5 to ± 50 g.

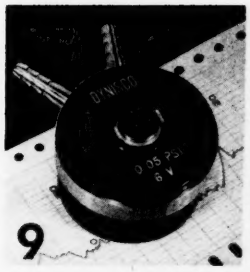
6 **MINIATURE PRESSURE PICKUP** of Dynamic Instrument Company has minimum output of 5 millivolts per volt excitation; maximum of 10 millivolts per volt excitation. Can be mounted flush with the inner surface of the pressure chamber to measure fast pressure variations. Units are available in pressure ranges from 0-3 to 0-300 psig, psid, or psia. Is shown actual size.

7 **TRUE-DIFFERENTIAL DC PREAMPLIFIER** Model 450-1300A of Sanborn Company has gains of 1000, 500, 200, 100, 50 and 20.



8 **CARRIER AMPLIFIER** Model 450-1100 of Sanborn Company has carrier frequency of 2400 (standard), 600, 1200, or 4800 cps. Frequency response is 3 db at 20% of carrier frequency. Includes zero suppression.

Instruments



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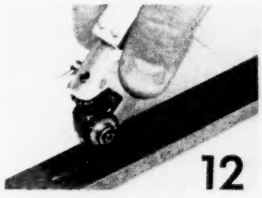
9 **ULTRA-LOW-PRESSURE D-P TRANSDUCER** of Dynamic Instrument Co., uses unbonded strain gages for differential pressure ranges of 0.05 to 0.5 psid full-scale. Excitation is 6 v, ac or dc; output is 3.5 mv/v full-scale.

10 **STRAIN-GAGE TORQUEMETER** and Type 5-119 Recording Oscillograph of Consolidated Electrodynamics Corporation in use on a motor test. Motor is loaded by inertia wheel; torquemeter uses four SR-4 strain gages in bridge.

11 **PORTABLE STRAIN INDICATOR** of Sanborn Company includes Model 150-1100 carrier preamplifier, power supply, and null-balance indicator. Features amplifier sensitivity of 400 microvolts input for full-scale deflection.

12 **WELDABLE HI-TEMP STRAIN GAGE** of Micro-Test, Inc., has a dynamic test range to 1600°F. Can be spot welded by "Rollectrode" tool and test-ready on flat or curved surfaces in less than five minutes. Available gages have a nominal resistance of 60 ohms and a gage factor of 1.85. Dimensions of available gage types are 1.250" x 0.125" and 0.750" x 0.250".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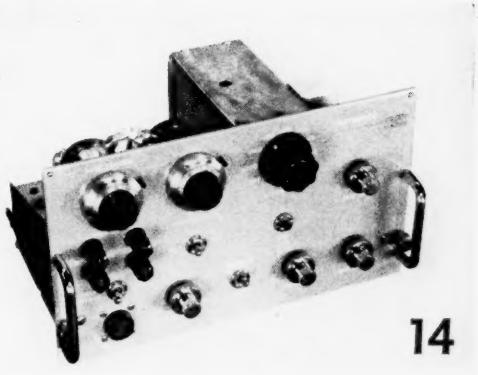
13 **PRESSURE TRANSDUCER** Model P222 of Statham Instruments, Inc., features flush diaphragm and tiny size (diameter 0.25", length 0.47", weight 3 grams). Using unbonded strain gages, the circuit forms a 200-ohm bridge.

14 **CARRIER PREAMPLIFIER** Model 150-1100 of Sanborn Company comprises an oscillator for exciting transducers, bridge balancing networks, a carrier amplifier, and phase-sensitive demodulator. With appropriate transducers it can measure strain, pressure, displacement, flow, velocity, acceleration, temperature, and other physical phenomena. Frequency response is 0-100 cycles (1200-cps or 2400-cps excitation); 0-30 cycles (600-cps excitation).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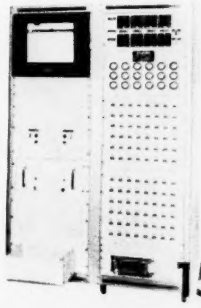
15 **HIGH-SPEED PLOTTER** Model 221 of Gilmore Industries, Inc., is 95-channel instrument, plots 20 strain-gage channels per second, and can be modified for millivolt input such as thermocouples. Ranges available: ± 2.000, 5.000, and 10.000 microinches across 5" vertical strain chart. Chart paper is 11" wide Teledeltos type with four graphs across the chart. 96 zero controls are furnished for initial balancing of circuits.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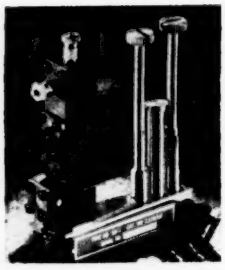
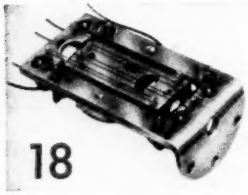
16 **STRAIN GAGE CONTROL UNIT** MR-21C of Instrument Div., Hamilton Watch Company, is multichannel unit with amplifiers, balancing controls, range controls, vernier sensitivity controls, and bridge calibration controls.

more strain-gage instruments





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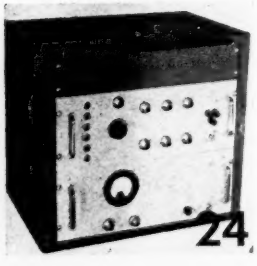

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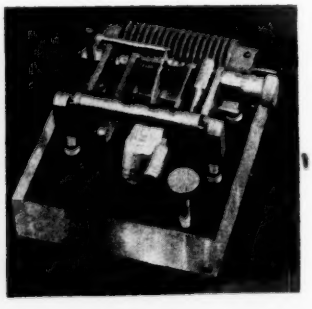


17 **BIFILAR GALVANOMETER** Type OA-2 of Hathaway Instrument Division, Hamilton Watch Co.

18 **UNBONDED STRAIN GAGE** of Statham Laboratories, Inc., can measure force or displacement by attaching a linkage pin to armature, which can move ± 0.0015". Same unit can be used as dynamometer, pressure pickup (by attachment to bellows or diaphragm), etc.

19 **ACCELEROMETER** Model A52 of Statham Instruments, Inc., uses unbonded strain gage principle. Dimensions are 0.32" x 0.35" x 0.97"; weight is 7.2 grams. Output is approximately 32 millivolts full-scale open-circuit with 8-v excitation. Circuit forms a complete balanced bridge with nominal resistance of 300 ohms.

20 **RESISTANCE BRIDGE INDICATOR** of Datran Electronics is a servo-balanced instrument for efficient use of resistance-bridge transducers such as strain gages, resistance thermometers, and load and pressure cells, and can be used also as a potentiometer. Features include automatic digital readout.

21 **JUNCTION BOX** Type WA of Hathaway Instrument Company can be placed at the strain-gage location so bridge is made up of short leads. One, two or four strain gages can be used in the bridge, using the fixed resistors within the box to make up the balance of the bridge.

22 **TELEDYNE PRESSURE INDICATOR** Model 182 of Taber Instrument Corporation comprises strain gages, dc power supply, and indicator. Uses include fluid and gas pressures, thrust, torque, etc.

23 **SWITCH AND BALANCE** unit BSG-6 of Ellis Associates prebalances resistance bridges and connects in selected bridge. Presets bridge balance and gain for each of six channels and accommodates 2- or 4-arm bridges. Features pushbutton channel selection.

24 **BRIDGE CONTROL PANEL** of Sanborn Company includes Model 150-1900 Master Oscillator Power Amplifier (MOPA), and has resistance balance controls for six bridges.

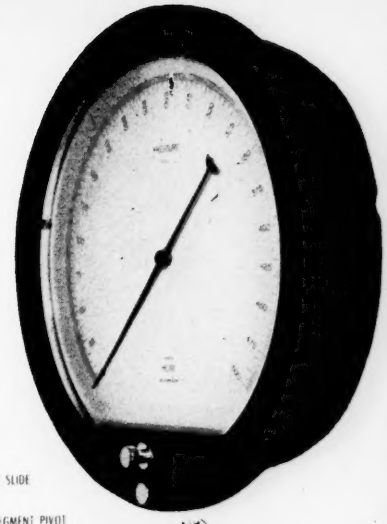
25 **CERAMIC STRAIN GAGES** Series-SC of Gulton Industries, Inc. are for determining characteristics of dynamic strains in structures. Sensitivities are said to be 50 times that of wire strain gages. Sizes range from ⅜" to 1" long and 1/16" to ¼" wide. Features: Simplicity of associated circuits, prepolarized piezoelectric ceramic plates, high-frequency measurements.

26 **AUTOMATIC STRAIN GAGE TRIMMER** of Baldwin-Lima-Hamilton Corporation speeds up gage trimming by as much as ten times, and allows better seating of the gage when applied to the element. Unit provides an illuminated plexiglass base, with etched positioning lines and a gage-holding fixture. A precision micrometer adjustment positions two cutting knives which can be used simultaneously for trimming both edges of a gage within 0.002".

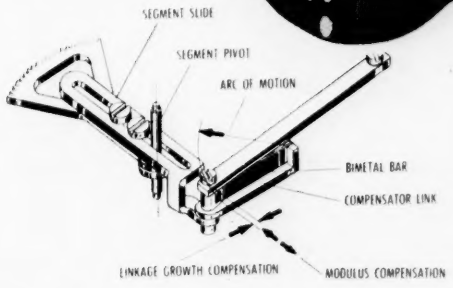
Thermal Compensator for Bourdon Gauges

OTTO W. HEISE

Heise Bourdon Tube Company



PRECISION pressure gauge and mechanism with thermal compensator.



PORTABLE self-indicating instruments for measuring time, temperature, volume and length had been brought to a high level of precision by the mid '20's, but up to that time the measurement of fluid pressures lagged.

Pressure gauges of 30 years ago were generally accepted to be accurate to about 2½%, and "master" or "test" gauges could be procured to an accuracy of about 1%. Although more accurate measurements could be made with a dead-weight device, the lack of a precision self-indicating pressure instrument which could be mounted in a test stand in conjunction with other equipment was a serious handicap to many research programs.

In 1927 the Heise Bourdon Tube Company was asked by the late A. H. Emery and his partner A. C. Tate to provide a self-indicating gauge with an accuracy of 1/5 of 1%, to be used for testing concrete specimens and for the building of a machine for testing the physical characteristics of metals. In order to produce a Bourdon tube which would fill these requirements, research was begun on materials and tube design to reduce hysteresis and drift. The results of this work were so successful that precision Bourdon gauges have since been widely used in place of the "dead weight" tester as a reference standard. The modern high precision pressure gauge movement (Fig. 1) which resulted from these and other improvements through the years is now a scientific instrument capable of maintaining calibration indefinitely at pressures from 10 to 30,000 psi. to within 0.1%.

The one remaining difficulty in the convenient use of a pressure gauge in test-stand conditions has been in the thermal instability of materials. In all such instruments, linear expansion and contraction of linkages has resulted in an angular displacement of the pointer, introducing an error of about 0.1% for each 5 Fahrenheit degrees of temperature change.

The problem was complicated by the change in Young's modulus in the metal of the Bourdon tube, which results in a further error of about 0.1% per 5 Fahrenheit degrees of change.

Most manufacturers of pressure gauges advise their customers that their gauges are accurate only at the temperature at which they were originally calibrated. They also publish corrective figures or charts for use when it is impossible to maintain ambient temperatures exactly that at which the gauge was calibrated.

An ingenious new Thermal Compensator automatically corrects for *both* temperature change in Young's modulus of the Bourdon tube and temperature change in linkages—a long-sought development.

A bimetal bar which deflects to provide angular motion proportional to the change in temperature is assembled between the end of the segment slide and the linkage from the moving end of the Bourdon tube. The arc of motion thus provided may be considered as having two components—one to move the segment slide angularly about its pivot to compensate the error resulting from the growth of gauge members, the other to alter the effective length of the segment slide by which the movement of the Bourdon tube is multiplies (and thus to correct for changes in the modulus of the tube).

With this development, pressure gauges now can be used to provide direct readings accurate to 0.1% on pressures up to 30,000 psi with temperatures varying from 0 degrees to 110 degrees F.

New methods for producing a Bourdon tube are expected to raise the maximum pressure to 50,000 psi. Other new developments include an external bleeding device which evacuates air or gas from the gauge tube without disturbing the gauge mountings, and a dial graduating process to insure accuracy and legibility in the dial face.

ELECTRONIC

MILTON H. ARONSON
Instruments & Automation

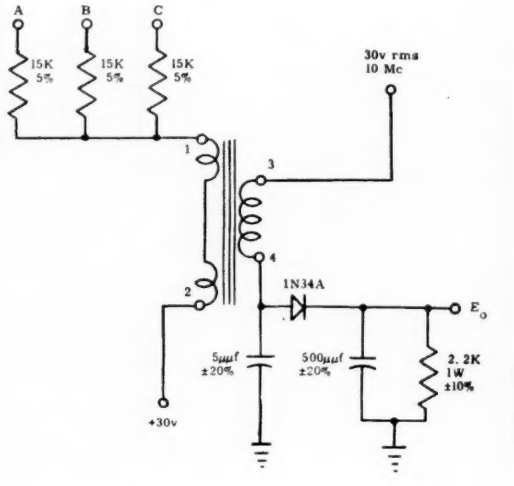
and

CHARLES F. KEZER
Digitronics Corp.

SATURABLE-REACTOR TRIPLE-COINCIDENCE GATE

A coincidence (or "AND") circuit delivers an output pulse only when all of its two or more inputs are present simultaneously. A previous triple-coincidence circuit (100 *Electronic Circuits*, circuit 63, p. 112) uses a vacuum tube and semiconductor diodes; the circuit shown here uses a saturable reactor, available from supplier as "Ferristor" type 41-13. The tiny (9/16" cube) saturable reactor offers increased reliability over the vacuum tube. It is cast in epoxy resin. As the device generates little heat, cooling problems are also reduced.

Note: An AND and an OR gate are the same thing. If an AND gate delivers two outputs, say output 1 for A, B, *AND* C inputs present, then it obviously delivers its other output for either A, B, *OR* C (*or* any combination) not present, indicating the OR condition.



Circuit depends for its operation on the change in inductance of the *controlled winding* 3-4 which is produced by passing direct current through the *control winding* 1-2. When all three inputs A, B, and C are at 30-v potential, there is no direct current flowing in the control winding 1-2, and the inductance of the controlled winding 3-4 is at its unsaturated value of 120 uh. Terminal 3 of the latter winding is connected to a 10-Mc signal generator which applies 30-v rms at low impedance. The 10-Mc current, passing through winding 3-4, then develops a voltage across the 5-uuf capacitor which is rectified by the 1N34A diode, producing an output Eo of 8 volts.

When any one of the three inputs changes to its lower level of 0-v dc, nearly 2-ma dc flows in the control winding 1-2. Flux in the core of the reactor approaches saturation level, and the inductance of the controlled winding 3-4 drops to 6 uh. This reduction in inductance allows a larger 10-Mc current to flow, and the output Eo rises to 30-v dc. Further increase in control winding current, as when more than one input is at 0 v, produces negligible change in output.

Input: Positive-going 30-v pulses.

Output: 8 v at coincidence; 30 v at non-coincidence, as shown in following table.

Input (volts)			Output (volts)
1	2	3	
0	0	0	30
30	0	0	(non-coincidence) 30
30	30	0	(non-coincidence) 30
30	30	30	(coincidence) 8

Circuit cannot respond to inputs instantaneously because of the lag in control winding current buildup and decay, resulting from the inductance of the control winding. Time constant is L/R and depends on input source impedance. When source impedance is small compared to the 15K input resistors, time constant is 8 usec or less. Using a higher impedance driving source will reduce the input time constant.

As the inductance of the controlled winding is much lower, rise and fall times of only 2 usec are obtained at the output.

Output rise time: 2 usec.

Output fall time: 2 usec.

Saturable reactor specifications: Control winding inductance is 40 mh unsaturated; 18 mh saturated.

Control winding resistance: 680 ohms.

Controlled winding inductance: 120 uh unsaturated, 6 uh saturated (measured at 1.7 Mc).

Controlled winding resistance: 4.5 ohms.

Max. carrier current in controlled winding: 100 ma.

Max. applied carrier voltage at rf supply: 35 v rms at 10 Mc.

Note: All voltages can be scaled down for lower power if desired. Example: 10 Mc at 10-v rms; inputs A, B, C = 10 v or 0 v; input resistors = 5K.

Supply voltage: 30 v rms at 10 Mc. Supply impedance less than 100 ohms.

Source: Berkeley Division, Beckman Instruments Inc., 2200 Wright Ave., Richmond 3, Calif.

MAGNETIC SCHMITT TRIGGER USES SATURABLE-REACTOR SWITCHING ELEMENT

The Schmitt Trigger circuit is well known in vacuum tube and transistorized form (*I&A*, September, 1957). This circuit uses a saturable reactor as the switching element. Like other Schmitt triggers it is used mainly to generate sharp pulses from slowly varying input waveforms.

The saturable reactor is available from manufacturer as "Ferristor" Type 41-12.

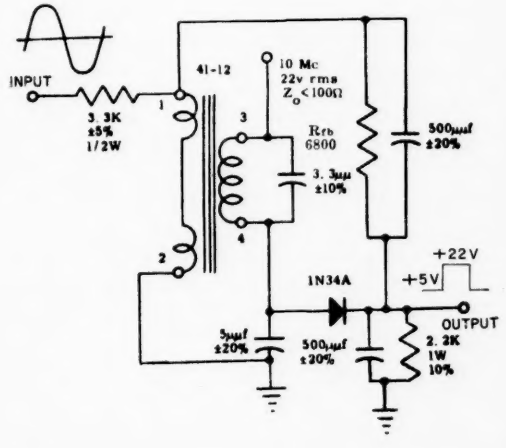
CIRCUITRY

The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

Triggering action is obtained by positive feedback, via the 6800-ohm resistor and 500-uuf capacitor (from the output to the control winding). At zero input voltage, the saturable reactor is in its unsaturated state, and inductance of the controlled winding is 120 microhenries. Most of the voltage of the 10-Mc carrier supply appears across the controlled winding, and the rectified 10-Mc output voltage is only 5 v dc.

As the input voltage rises, current in the control winding 1-2 rises correspondingly (with the output remaining constant) until the reactor begins to saturate at +5 volts input level. At this point (upper triggering level) the controlled winding inductance begins to fall, the output voltage rises and further increases the control winding current via the feedback loop (6800-ohm resistor and 500-uuf capacitor). This regenerative action quickly saturates the reactor. Output voltage is then +22 volts, and remains at this value as the input voltage increases.

Once the output is high (+22 v), signal current plus feedback current supplied through the 6800-ohm resistor hold the core saturated, and reverse switching action does not occur until the input voltage has decreased (below the value at which saturation commenced) to +3 volts. When the input voltage has fallen to this lower triggering level, the output voltage begins to drop as the reactor unsaturates, and the regenerative action rapidly returns the circuit to the original unsaturated state. Output voltage returns to the +5-volt level. The width of the hysteresis loop (difference between upper trigger level and lower trigger level) is a function of the feedback resistor (See Table). The upper trigger level is adjustable by magnetic bias.



Input voltage: Positive waveforms.

Upper input triggering level: +5 v peak.

Lower input triggering level: +3 v peak.

Hysteresis (difference between trigger levels) depends on R_{fb}:

R_{fb}	Hysteresis
5.6K	3.6v
6.8K	2 v
8.2K	1.3v
10 K	0.5v

Frequency range: 40,000 cps max.

Output: 17 v peak to peak.

Output rise time: 1 usec.

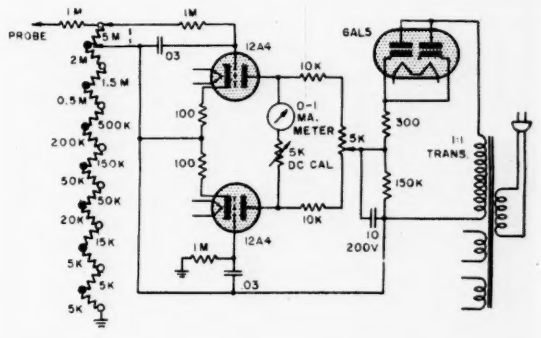
Output fall time: 2 usec.

Supply voltage: 22 v rms at 10 Mc; supply impedance less than 100 ohms.

Source: Berkeley Division, Beckman Instruments Inc., 2200 Wright Ave., Richmond 3, Calif.

VTVM HAS 0.5-V FULL-SCALE RANGE WITH NO PREAMPLIFICATION

Sensitivity of 15 to 20 times that possible with conventional vacuum-tube voltmeters of comparable stability is the outstanding virtue of this circuit. High plate-current operation of the type-12A4 bridge tubes makes possible sensitivity of 0.5-volt full scale on a 0-1 ma meter. Use of such high plate currents in conventional meters would normally be accompanied by errors due



to grid current. This is avoided in the VTVM by a unique range-switch arrangement which maintains the same amount of resistance between each grid and the common cathode return, balancing out grid-current effects.

Range switch shown is actually a two-wafer switch; the two wipers shown contact *alternate* switch points—that is, the common-cathode switch wiper contacts only the darkened contacts, the grid wiper contacts only those indicated by circles. Note that resistance from each grid to the common cathode return in switch position shown (0.5 v) is 6 megohms; in the 1.5-v position it is 2.5 megohms, and so on. Circuit shown is for dc voltage only, but it readily adapted for ac or resistance measurement by addition of diodes and additional resistor strings.

Input resistance: Constant at 10 megohms (plus 1 megohm in probe).

Ranges: 0.5 v in position shown; others are 1.5 v, 5 v, 15 v, 50 v, 150 v, and 500 v full-scale.

Source: CBS Hytron Release "Sensitive VTVM Uses Hytron 12A4, dated June 26, 1951; also *Electronic Design*, January, 1953.

Decentralized Computing With The Small Computer

THIS SMALL COMPUTER is being used by an engineering department as a complete, independent computing facility.

DIGITAL AUTOMATION—NO. 27

Examples show the way in which the small general-purpose computer is being used either to augment or to replace the large "giant" computer.

C. F. FLANNELL
Royal McBee Corporation

COMPUTERS have grown to be large and fast; they also have grown to be expensive and complex. The expense requires critical scheduling for efficient use, and the complexity makes scheduling difficult. In addition, efficient computer operation requires highly trained personnel who are difficult to find. Furthermore, the large computing installation is not flexible enough to keep up with the fast-changing demands of the engineering group. Hence, after the engineer learns to rely on the giant brain and use it regularly it becomes the source of several major obstacles.

First Problem: Programming

The first obstacle an engineer faces in getting a problem solved on a giant computer is having the problem programmed—that is, put into machine language. In a large computing installation of an aircraft company, a heat-calculation problem waited in line to be programmed for over six months. The engineers finally had to make a decision on the metal to be used in an air frame before they received the results of the heat calculations. If they had guessed wrong, thousands of dollars and a great deal of time would have been lost. This was an important problem and the engineers were unhappy with this delay in computing service. Many groups wait even longer for their answers.

Second Problem: Communication of Results

The second obstacle an engineer encounters in having a problem solved on a giant computer is the dual problem of communication and scheduling after the programming is completed. The data must be sent to the central installation each time a run is made. Companies which have large computers frequently are widely dispersed so that inter-office mail may require a half day for delivery. After the data arrives, they must be logged in, assigned a priority, punched in

Presented at Third International Automation Computer Clinic, Nov., 1956; also High-Speed Computer Conference, Louisiana State University, March 7, 1957.

cards or tape for entry into the computer, and wait until the machine becomes available.

Many engineers want their answers within a few minutes. One good example of this demand for quick results is in aerodynamic wind-tunnel applications. When a wind-tunnel test is completed, the engineers often want to see the results of that test before they set up the next test.

In research problems the engineer may first try a given set of values and then, when he sees the results, he may want to change one number slightly to observe the effect on the answers. If he must wait a day or two for his answers, he is less inclined to try a new value.

One method of improving communications is to feed data directly to the computer and receive answers immediately; the alternative method is to locate a computer at each source of data. Many large organizations have become interested in decentralized operation as a method of increasing the efficient use of their personnel and of breaking up the bottleneck created by "giant brains." The introduction of the small computer has made such decentralization possible.

Computers with large capacity have been developed which occupy less space than a normal office desk, which operate from a standard wall outlet, and which require no more power than an ordinary home iron. No air conditioning and no major overhaul of buildings to house them are required. The cost of installation of such a computer is small.

Use of Small Computers

There are three principal ways in which small computers are being used today. One way is to use several small computers as satellites to a large computer in order to reduce the difficulties attending the use of the large computer. Another way is to use a group of small computers to replace a large computer. A third way is to use the small computer by itself as the principal computing device for a company, division, or department. The expense of the large computer makes its use in this third case prohibitive. There are several interesting examples of such uses of small computers.

Augmenting a Large Computer

The head of the computing department of a large aircraft company, after a six-month feasibility study, recommended to management that they open the bottleneck of the central computing installation by purchasing a group of small computers to be located in various engineering departments. Their central computing installation operates on an "open shop" basis where the engineer does most of his own programming. This programming is simplified by an algebraic interpretive routine which translates algebraic expressions into computer language. The engineer can feel free to try new approaches to his problem on the small computer while his old approach is being employed on the large computer.

Program Checkout

Anyone who has worked in a central computing installation realizes that an engineer rarely states his problem in the first writing exactly as he wants it; invariably he wishes to make additions to the program or changes in the program almost immediately upon its completion. Debugging of new programs and program revision consume a great deal of machine time and, when the machine involved is a giant computer, time is expensive. In working through parts of a problem to find the source of difficulty, the greater speed of a large computer is of no advantage. An inexpensive man tends to become the slave of an expensive machine. A small computer whose code is compatible with that of the large computer can be used in this program checkout.

Department of a Large Company

Some large companies are taking still another approach to the application of small computers. Management has chosen to let each large department or division select a computer which will satisfy its own needs. The computing facility is on a completely decentralized basis. By having the computer close at hand, the engineer is encouraged to really make use of it, rather than waste his time on a desk calculator or content himself with educated guesses or "ball park" answers. For this type of installation care should be taken in selecting a computer which is relatively simple to program and to operate so that the engineer can spend more time concentrating on finding methods leading to more accurate answers than on programming and operating the computer.

The small company which cannot afford the price of a large computer or does not have enough work volume to warrant the use of a large computer may find use for an installation similar to that in a department of a large company. However, they must consider the capacity of the machine. In the small company, when a problem is encountered which is difficult to squeeze into the small computer, there is no large computer standing by which can be used. Hence, it becomes even more important for the small company to select a computer which has adequate capacity for a broad range of problems.

Use as Special-Purpose Computer

Another interesting application of a small-sized computer on a decentralized basis is its use as a special-purpose computer. For example, a major oil company is using an LGP-30 in one of its refineries to assist in the one difficult task of finding a combination of operations that will produce the desired motor fuels, on any particular day, from the crude that is presently available. In this application the use of a central computing service is inadequate because immediate answers are important. Accurate solution of this problem can mean as much as $0.01 to $0.02 per barrel difference in profit. Since over 100,000 barrels per day are involved in this operation, computation can make as much as $1,000 to $2,000 difference in profit per day.

These examples show the way in which small computers can be used either to augment the large computer or to replace it.

ANOTHER NEW LESLIE PRODUCT

ADJUSTABLE PROPORTIONAL BAND LIQUID LEVEL CONTROL

...with adjustable level ranges up to 0-200"

Here is a new differential pressure-type liquid level control pilot that combines the wide adjustable level ranges in the table shown below with a 2-20" or 7-25" adjustable proportional band.

ADJUSTABLE LEVEL RANGE — INCHES	ADJUSTABLE PROPORTIONAL BAND (INCHES, H_2O)	CONTROL PILOT TYPE
0-40 or 0-87	2-20	LAP
0-30 or 0-91	2-20	LABP
0-200	7-25	LAUP

Maximum Static Pressure — 300 psi

One Knob — Easy Adjustment

A single knob adjustment quickly sets the proportional band where you want it, even while the system is in operation. The liquid level is maintained constantly within that band until you re-set the control pilot for new conditions.

Applications

Leslie-Level-Matic Control Pilots are used in either open or pressurized vessels to control the level of virtually any liquid including water, gasoline, oil and chemical solutions. The new control pilot is particularly useful to maintain constant levels where there are high flow rates through vessels with small cross sectional areas.

Float Cages Eliminated

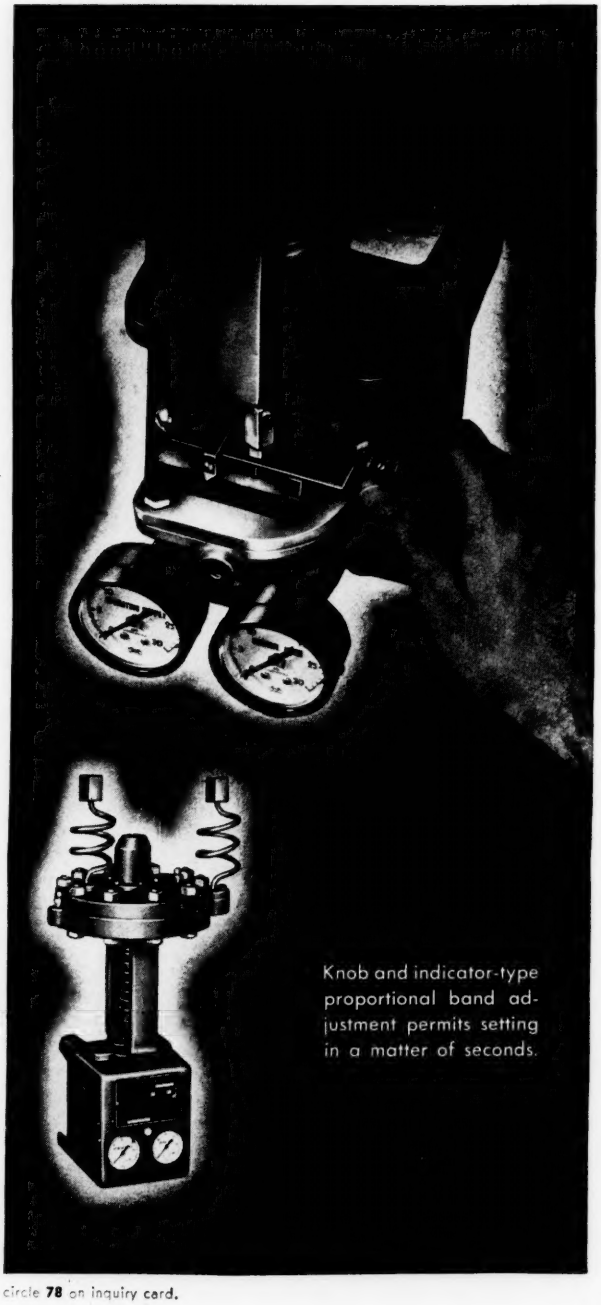
There are no floats or cages needed for Leslie-Level-Matic Control Pilots, and no torque tube seals, stuffing boxes, or thermohydraulic systems. All of the primary control elements are in one place and may be installed with a fraction of the effort and cost required for displacement-type controllers.

Vibration-Proof, Dependable

All of the dependability factors for which Leslie products are so well-known are incorporated in this new control pilot, as well. Rugged, accurate, stable — it is unaffected by normal vibration or turbulence.

More Information

Send for Engineering Data Sheet describing this new Control Pilot and outlining its principle of operation.



Knob and indicator-type proportional band adjustment permits setting in a matter of seconds.

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Fig. 9-1. Symbol for safety-relief valve. Letters in circle identify type—TSV (temperature safety valve), PSV (pressure safety valve), or SSV (speed safety valve). Symbol and identification are from Recommended Practice 5.1.1, Instrument Society of America.

Safety-Relief Valves--- Where they are needed and Why

Regulators No. 9

THE SAFETY RELIEF VALVE (Fig. 9-1) protects process equipment against all possible hazards, of which fire and other unforeseen sources of heat rank foremost. Also, failure of instruments or equipment, blocked lines, water hammer, abnormal conditions caused by human error, etc., can cause overpressure or vacuum which must be relieved if it can possibly exceed safety design ratings.

A valve inadvertently closed by an operator can cause rupture of a pump or compressor. Fractionating columns need protection against a blocked overhead vapor line while heat continues to be fed to the columns. Loss of reflux (which acts as a coolant) can cause overpressure. Pump failures or heat-exchanger tube rupture are sources of unexpected overpressures. Water hammer in pipes caused by sudden closing of a valve is a potential threat to piping. In all these and similar cases, safety-relief valves are mandatory.

Engineers must use considerable imagination to protect equipment against all hazards. In general, equipment connected together by piping that does not contain valves which can isolate any item can be considered as one unit for relief-valve analysis. If the items can be separated from one another by valves in the connecting piping, then each item will require its own individual relief valve (Fig. 9-2).

Fire is listed first and is number one in the minds

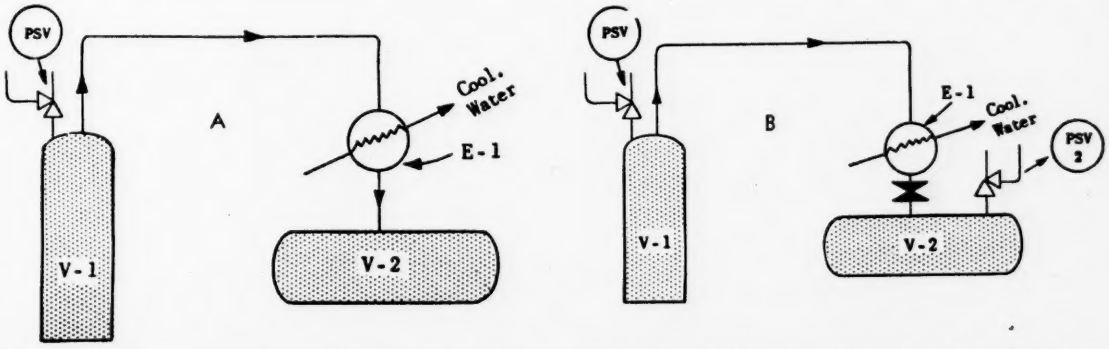

Fig. 9-2. (A) Interconnected equipment units which cannot be isolated from each other can be treated as one unit and protected by PSV-1. (B) Interconnected equipment units that can be isolated by a block valve must be treated as separate units and each protected by a relief valve; PSV-1 protects interconnected units V-1 and E-1, but block valve between E-1 and V-2 necessitates relief valve PSV-2 for V-2.

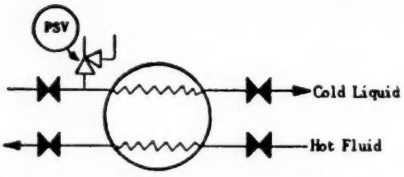

Fig. 9-3. Heat exchanger requires relief protection on cold side because the cold-side lines could possibly have heat applied from the hot lines while blocked.

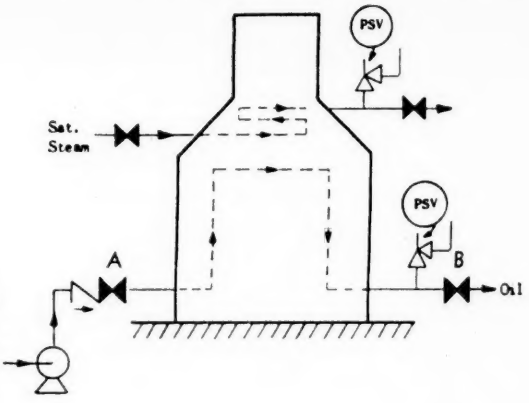

Fig. 9-4. Relief valve on direct-fired heater is placed on the coil outlet to permit flow through the coils even though line is blocked, and thus prevent coking; relief valve on super-heater steam coil is required because of possibility of starting up heater with steam lines blocked and condensed liquid in the steam coils.

of safety engineers in petroleum refineries and chemical plants because it is a prevalent and devastating hazard. The pressure developed in a vessel containing liquid that is exposed to fire will be a function of the temperature and composition of the liquid-vapor state. The way a safety valve keeps the pressure down is to provide an escape of proper size for the vapors generated. (Sizing will be discussed in the next chapter.) The types of equipment that risk fire are heat exchangers, fractionating columns, storage vessels, and operating vessels.

Blocked Outlets and Inlets

Liquid-filled lines that can be blocked in should be protected by relief valves if the lines are exposed to the sun. The sun on bare pipe can create enough pressure to rupture the piping.

If the cold side of a heat exchanger is liquid filled and can be blocked, then the cold side requires a relief valve (Fig. 9-3). It is possible to close the block valves on the cold side of the heat exchanger while hot liquid passes through on the "hot" side. Thus the "hot" side can transmit heat to the blocked-in liquid and rupture the shell.

A direct-fired heater with liquid oil in the coils requires relief protection when the coils can be blocked in. In Fig. 9-4 the coils can be blocked in by closing the two block valves "A" and "B," or by closing the outlet block valve when the check valve prevents any reverse flow, or by having the outlet block valve closed and the pump pumping liquid. When input is pumped, the relief valve should be placed on the coil outlet side to permit flow through the coils and thus prevent coking.

In the arrangements shown in Fig. 9-4 it is also possible to start up the heater with the valves on the steam coils closed and liquid condensed in the coils. In view of this possibility it is necessary to insert a relief valve on the super-heater steam coil.

Overpressure also can be developed in fractionating columns (Fig. 9-5) if the block valve in the overhead vapor line is closed accidentally and heat continues to the column. This necessitates use of a relief valve on the column. Fig. 9-5 also shows how the loss of reflux can cause overpressure to the column because reflux acts as a coolant. Reflux failure can be due to pump failure, instrument failure, or loss of cooling water.

Pumps

Positive displacement units discharge constant volumes of liquid, gas or vapor. The fluid cannot reverse itself but must go forward with the motion of the piston or gear. If the discharge is blocked and the fluid cannot go forward, then the pump will either stall or the pump or associated piping will rupture. Relief valves are installed as shown in Fig. 9-6 to pro-

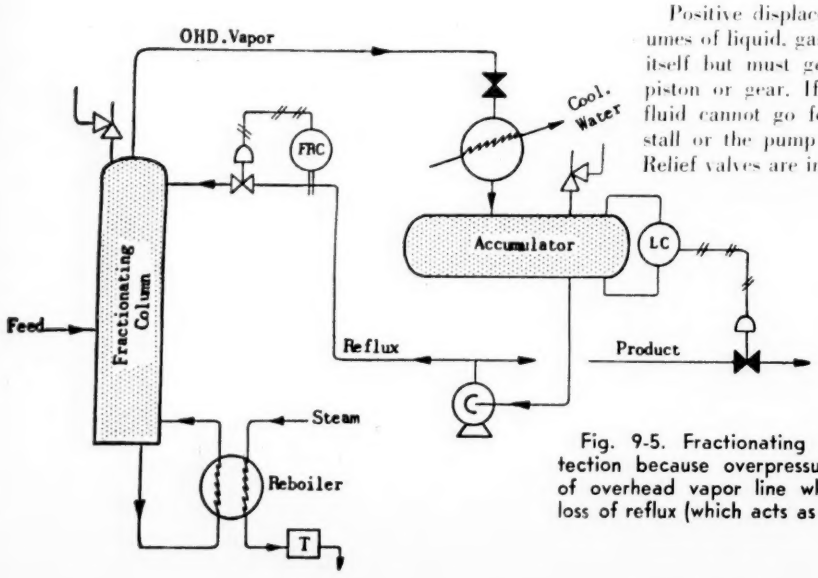

Fig. 9-5. Fractionating column requires relief protection because overpressure can result from blocking of overhead vapor line while heat continues, or from loss of reflux (which acts as coolant).

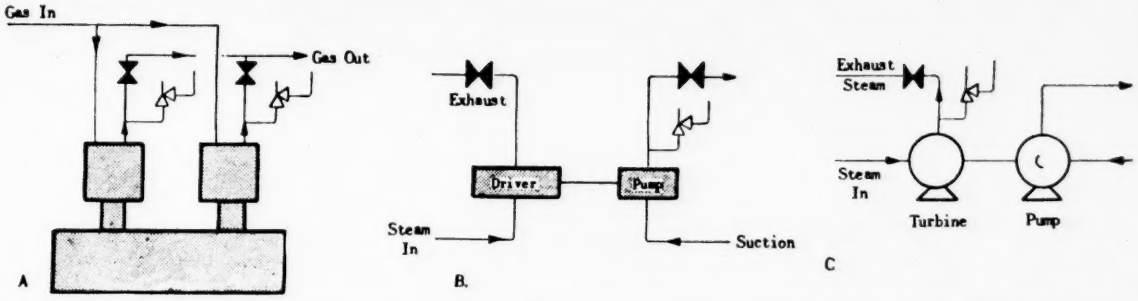

Fig. 9-6. Pumps require relief protection against blocked outlet lines. A is reciprocating compressor; blocked outlet could rupture compressor case or lines. B is reciprocating pump or gear pump, which also could rupture if outlet lines were blocked. C is turbine drive which requires protection on exhaust side because exhaust side is designed for lower pressure than inlet side, and blocked outlet would cause outlet pressure to rise to inlet pressure.

tect the equipment. (Note—in A and B the relief valves may discharge to the suction side of the units.)

Instrument Failure

Another important feature to guard against is instrument failure, including loss of air to the instruments.

One common instrument-failure possibility is a control valve "freezing" in an open or closed position (Fig. 9-7). If control valve FRCV freezes in an open position and the overhead condenser is not designed to condense the full capacity of the steam through the control valve, or if the block valve between the condenser and accumulator is closed, then it is possible to overpressure the column.

Entrance of a fluid or vapor from a high-pressure system to a low-pressure system can be a source of equipment overpressure. In Fig. 9-8 the absorption of wet gas with lean oil takes place at 450 psig. The rich oil leaves the aborber through a pressure-reducing level-control valve to the deethanizing column, which operates at 200 psig and has a maximum design pressure of 250 psig. If the control valve were to freeze in an open position, then it is possible to feed an excess of high-pressure liquid and gas to the deethanizer; relief protection must be provided.

Other possible instrument failures are (1) steam or hot oil control to a reboiler, (2) cooling-water control on a condenser or cooler, (3) steam control to a turbine, (4) pressure control on a fractionating column, and (5) steam boiler controls.

Vacuum Relief

Equipment not designed for vacuum service must be protected against underpressurizing as well as overpressurizing. Full or partial vacuum in equipment can be caused by (1) pumping more liquid out of a vessel than is entering, (2) draining liquid from a vessel (such as water after a hydrostatic test) without venting, and (3) injecting cold liquid into a vessel after steaming it out—because the cold liquid can condense the steam, thus producing a vacuum.

Acknowledgment

This material is an extension of the article "Why a Relief Valve," by Joseph Conison, The Ralph M. Parsons Company, *I&A*, June 1955.

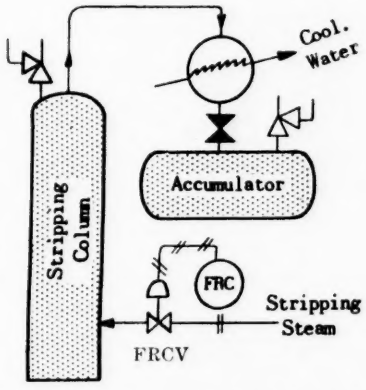

Fig. 9-7. Example of protection required against instrument failure. If valve controlling 135-psig stripping steam to stripping column should freeze open, the column (designed for 50 psig maximum) might be subjected to 136-psig steam pressure if overhead condenser is not designed to condense full steam capacity or if the block valve between the condenser and accumulator is closed.

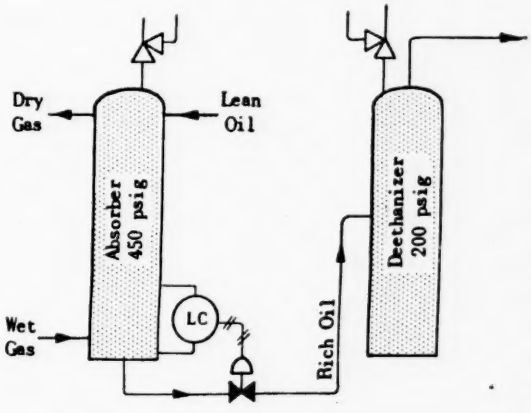

Fig. 9-8. If control valve between 450-psig absorber and 200-psig deethanizer of this absorption unit were to freeze open, pressure in deethanizer could exceed its design rating.

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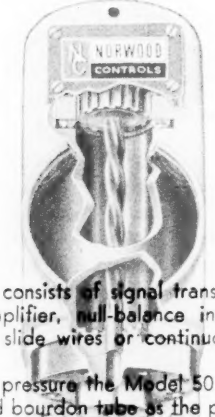

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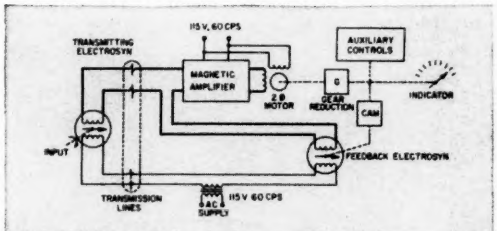

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Journal of the S C M A . . .

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The characteristic curves of control valves, which are based on constant control-valve ΔP, are inadequate for proper design of a control valve located on the discharge of a centrifugal pump. Here is a simplified and standardized procedure for determining the actual pressure drop across the valve, and for optimum design of the pump system.

JOSEPH CONISON
The Ralph M. Parsons Co.

Why Fight Valve ΔP in Pump Discharge?

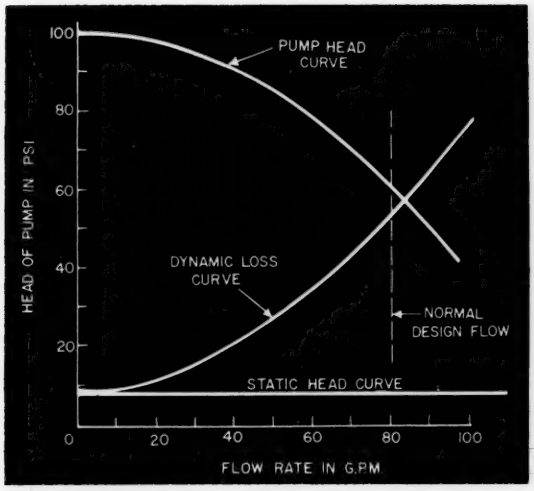


FIG. 1. PUMP HEAD CURVE of a system with little additional capacity above normal design rate and with poor controllability.

Presented at 32nd Fall Meeting of CNGA, Oct. 1957, Los Angeles.

APRIL MEETING: Thursday, the 17th, Rio Hondo Country Club, Downey, California.

FEATURE: Mr. Paul Wing, Chief Engineer of Mason-Neilan Division, Worthington Corporation, will discuss, "Selecting Control Valve Trim for High Pressure Drop and Erosive Service".

Design It!

A STANDARD PROCEDURE for determining the required design pressure-drop across a control valve located on the discharge of a centrifugal pump was urgently needed in our organization, as in many other engineering construction companies. An investigation of available standard procedures among engineering and operating companies revealed only a few procedures, and one company's standard would not be accepted by another because of divergent requirements. It was decided to develop a new standard, based on sound engineering principles, of wider applicability and acceptance.

Fig. 1 shows a pump head curve of a system with little additional capacity above normal design flow and poor controllability (non-linearity). We patterned our approach after that shown in Fig. 2, which has (1) additional flow rate above design flow and (2) sufficient control valve ΔP for controllability at the additional capacity.

Establishing Pump Capacity

A check of the design capacity of related equipments revealed that, in general, they are designed to process a maximum of 10% over the normal design rate.* The only exception was reflux pumps and,

*Normal design is based on the design of the unit. If the unit is designed to process 10,000 BPD, then the *design* capacity of each item is based on the ability to process its phase of incoming feed of 10,000 BPD to the unit.

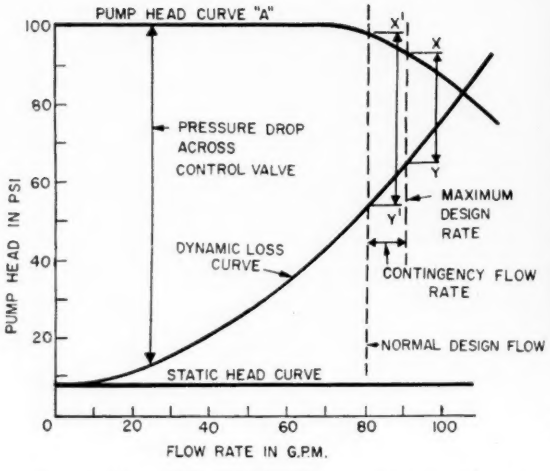


FIG. 2. PUMP HEAD CURVES of system with adequate design capacity and good controllability.

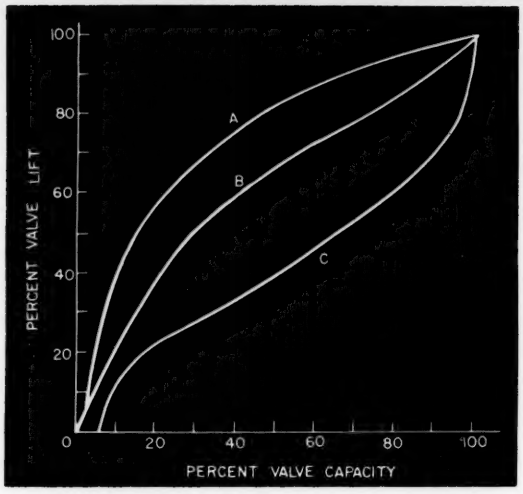


FIG. 3. LIFT VS CAPACITY. Curve A shows characteristic of percentage plug with entire system drop across valve (constant ΔP). Curve B shows characteristic of same plug with variable line friction (10 psi across valve and 40-psi line friction at maximum flow). Curve C shows characteristic of same plug with only 2 psi across valve and 40-psi line friction at maximum flow.

occasionally, water pumps. The reflux pumps were sized as much as 25% over the normal design rates because this service is subject to changes in feed composition, ambient temperatures, and cooling water temperatures.

It was agreed to establish a maximum design rate* for the pumps (exceptions to be dealt with as occasion arises) at 1.1 times the normal design rate for the equipment associated with the pumps. In this manner, all over-design of the equipment will match with one another. After firming up the pump capacities, the next step was to determine the control-valve capacities.

Establishing Control-Valve Capacity

A check with various control-valve manufacturers indicated that good control can be obtained with control valves up to 95% of their rated capacity. Thus a control valve rated at 100 gpm at 10-psi ΔP can increase or decrease flow when at 95 gpm and at 10-psi ΔP. As the valve should be able to control the full output of the pump, it was decided that the control valve must have a rated capacity of at least 5% over the maximum design capacity of the pump.

The following example will show how design rates can be determined using these proposed standards:

1. The process engineer establishes the normal design rate through the unit at, say, 100 gpm.

2. Then the pump maximum design rate (rated capacity) will be 110 gpm (10% over normal design rate).

3. The control valve located on the discharge of the pump will be sized at a maximum design rate of 5% above the pump rated capacity, or 1.05 times 110, or approximately 116 gpm. The valve may be sized for a capacity greater than 116 gpm, but not less.

Determining Valve Characteristic Curve with Variable ΔP

It was decided to develop valve characteristic curves to determine the *minimum usable pressure-drops* across the control valve because no two engineers or manufacturers agree on a usable ΔP, nor do they substantiate their data.

Control-valve characteristic curves (% valve stem-lift *vs* % valve capacity) are readily available at constant ΔP across the valve, or where the ΔP in the system is 100% across the control valve. For example, curve A in Fig. 3 shows a typical valve characteristic at constant ΔP, or with 100% of the system drop across the valve. But, if the control valve is in series with exchangers, heater, etc., curve A can not apply. It is necessary to develop a characteristic curve for the valve subjected to *variable pressure-drop*. This can be done from curve A of Fig. 3.

Table I illustrates the steps used in obtaining a variable-ΔP characteristic curve. For simplicity in calculation, a constant discharge pressure was used. At a maximum flow of 60,000 gph, the line friction or dynamic loss* is 40 psi, and the control valve ΔP is 10 psi. As the flow decreases, the line friction loss decreases, and the ΔP across the control valve increases. At zero flow the ΔP across the valve is 50 psi. F_r in Table I is the quantity of fluid that can pass through the fully opened valve at the corresponding

*Maximum design is the "rated" capacity of a piece of equipment, generally greater than normal design.

*Dynamic loss in this discussion will refer to fluid friction such as in the line, exchanger, and heater, but not static losses or control valve ΔP.

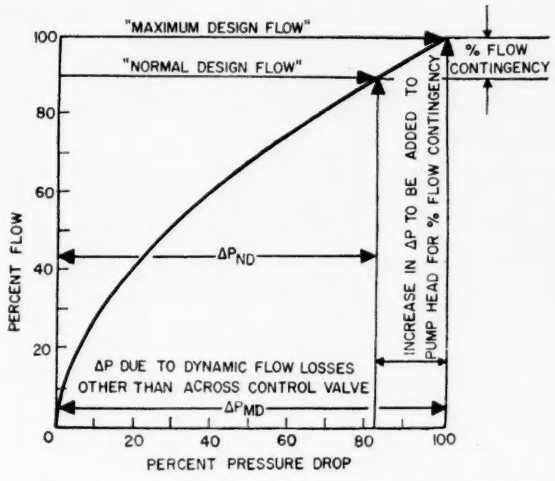


FIG. 4. SYSTEM DYNAMIC pressure drop vs percentage flow rates.

ΔP across the valve. The ratio (F_1/F_t) is the ratio of the actual flow of gpm to the potential maximum flow at the corresponding ΔP. From this ratio, one can obtain the % stem lift by referring to the % Stem Lift *vs* % Valve Capacity curve at constant ΔP (curve A in Fig. 3).

Curve B in Fig. 3 is a plot of % Valve Lift *vs* Actual Flow (F_1), as taken from Table 1.

Determining Minimum Allowable Control-Valve Δp

To obtain the minimum required ΔP across a specific valve, a plot is made as in Table 1, where the ΔP across the valve is continuously decreased until a curve of reversible characteristic develops, at which point the control obtainable is not desirable.

Such a curve was developed (Fig. 3, curve C) from a set of conditions where, at maximum flow, the control valve ΔP is 2 psi and the dynamic losses are 40 psi.

It was agreed to limit the minimum ΔP across the valve to approximately 15% of the dynamic losses in the system, or 10 psi, whichever is greater, and at its maximum design capacity.

The 15% of dynamic losses was selected because it is definitely above the minimum ΔP for obtaining satisfactory control rangeability, and below the 25% which exhibits almost ideal characteristic curves. Using the vernacular in the industry, 15% is "not too fat or too lean." The alternate of 10 psi was selected because of past experience wherein a valve of less than 10 psi ΔP invariably resulted in a valve size larger than line. Under the most adverse conditions, the size of the control valve selected is limited to a maximum of "line" size.

TABLE 1—DERIVATION OF DATA FOR PLOTTING CURVE B IN FIG. 3 FROM CURVE A

% Flow	Actual Flow Thru Line G.P.H. (F_t)	Line Loss PSI ΔP_f	P Across Valve PSI ΔP_v	Max. G.P.H. Thru Valve at ΔP_v F_t	% Max. Flow (F_1/F_t) 100	Valve Lift (%)
100	60,000	40	10	60,000	100	100
80	48,000	24	26	85,000	56.4	85.5
60	36,000	12	38	102,000	35.3	72.2
40	24,000	6	44	110,000	21.8	59
20	12,000	1.8	48.2	118,000	10.1	39
0	0	0	50		0	0

"Short Cut" for Extending Friction Losses

The next step was to provide a tool for engineers (1) to extend the normal design friction losses to the maximum design losses and then (2) to calculate the control valve ΔP.

This tool turned out to be a simple System-Dynamic-Pressure-Drop *vs* Percentage-Flow-Rate curve (Fig. 4). With this curve, valve ΔP can be obtained for any increase above the normal design rates.

For example, if the normal design is 90% of the maximum design, let us find the friction losses at maximum design from the data based on normal design. Referring to Fig. 4:

1. At normal design of 90% flow, assume the dynamic losses are 82% on the curve $=\Delta P_{ND}$.
2. At maximum design of 100% flow, the friction then is 100/82, or 1.22 times the normal design dynamic losses $= (\Delta P_{MD})$; or 10 psi, whichever is the greater.

Conclusions

We can now tailor the design of pumps and control valves located on the pump discharge to the over-all plant design by building into the pump head:

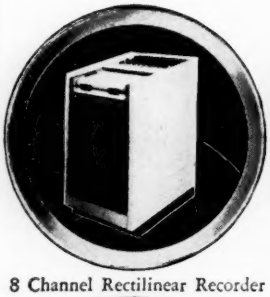
1. A capacity equal to a minimum of 1.1 times the normal design rate for general services, and higher for special cases.
2. Sufficient differential head to compensate for the maximum design rate (1.1 times normal design rate).
3. Control-valve pressure drop equal to a minimum of 15% of the dynamic losses at maximum design flow—or 10 psi, whichever is greater.

This technique presents:

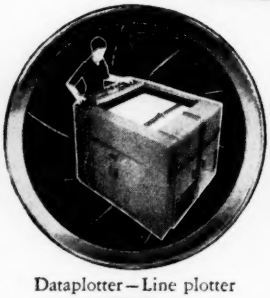
1. An economical initial cost.
2. An efficient plant operation.
3. An increase of over-all plant capacity extension.
4. A good process control system.
5. A simplified procedure that expedites a project through engineering.

Acknowledgement

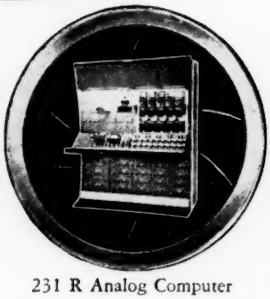
The writer thanks the management of the Ralph M. Parsons Company for permission to publish this paper; also the members of the Ralph M. Parson's engineering sections and representatives of control valve manufacturers for constructive comments.



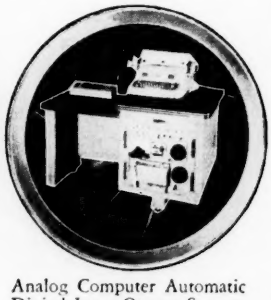
8 Channel Rectilinear Recorder



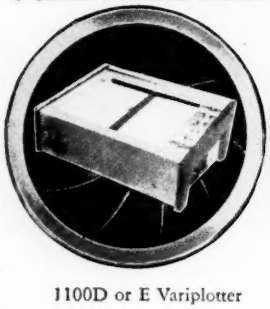
Dataplotter—Line plotter



231 R Analog Computer



Analog Computer Automatic Digital Input-Output System



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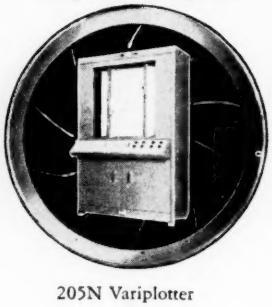

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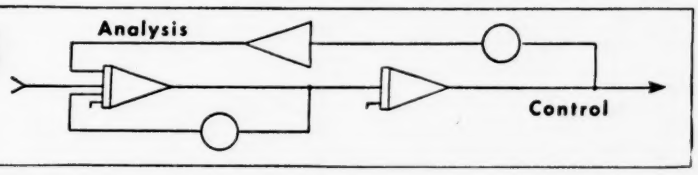

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Bits

THIS MONTH, we report on the joint Western Simulation Council, DDA Council, and Los Angeles chapter, ACM meeting at Ramo-Wooldridge in January on the "Interrelationship of Analog and Digital Computers." Papers presented compared the different types of computers and a combination of a general-purpose analog with a general-purpose digital computer. They also described the simulation of an analog computer and a digital differential analyzer on general-purpose digital computers.

Notable by its absence was any mention of simulating a digital on an analog computer—which we understand has been done by Lou Wadel at Chance-Vought and also at Hughes!

Pieces

JOINT MEETING OF 8 JANUARY ON "INTERRELATIONSHIP OF ANALOG AND DIGITAL COMPUTERS"

One hundred and eleven people were counted at the joint meeting of the Western Simulation Council, the DDA Council, and the Los Angeles chapter of the Association for Computing Machinery held at Ramo-Wooldridge Corporation in Los Angeles on the afternoon of 8 January 1958.

Curl on Comparison of Computer Types

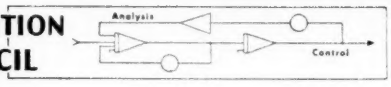
The technical session was opened with a paper by *Frank Curl* (Jet Propulsion Laboratory, Pasadena, Calif.) entitled "A Comparison of General-Purpose Digital, DDA, and Analog Computers." Frank said that when comparing computers the following points must be considered: Cost, problem size, accuracy required, maintenance, ease of use, speed, kind of outputs, reliability, staff required, limitations.

The GPD Computer

Choosing the Datatron as representative of general-purpose digital computers because he has had experience with it, Frank explained that this is a medium to slow-speed computer with a 4,000-word main and an 80-word high-speed memory of 8.4 and .48 ms access-time respectively, costing less than $200,000. The size of the problem that such a computer can solve depends on the memory size. Programmer ingenuity and double-precision techniques can yield 20-digit accuracy. Eleven percent of computer time must be devoted to maintenance. Sub-routines and interpretive routines allow use by personnel with little training. For comparable accuracy the speed compares favorably with that of an analog computer. The outputs are tabulated unless auxiliary plotting equipment is used. Reliability is unquestioned "provided the machine has been instructed to perform the proper operations and is operating correctly."! The staff required is comparatively large, which makes for high cost per hour, but usually not much actual computer time is required.

The DDA

DDA's cost much less, and work by *George Forbes* (Litton Industries, Beverly Hills, Calif.) and *Max Palevski* (Packard-Bell Computer Corp., Los Angeles, Calif.) indicates that



their capacity is greater than generally supposed, though there are usually fewer than the equivalent of 60 analog amplifiers. Accuracy is usually about six digits, but a DDA requires a great deal more maintenance than either a general-purpose digital or an analog computer. After a simple code has been learned it is as easy to use as an analog, but for comparable accuracy the DDA is much slower than either an analog or a GPD. Outputs are tabulations or graphs, and reliability is that of a digital computer (if the registers are the same length). Only a small staff is required, and on a rental basis a DDA can be operated for about $40.00 an hour. Greatest disadvantage is that the DDA's serial operation is very slow.

The Analog Computer

"An analog computer is a thing of beauty and a joy forever." A medium-sized (144 amplifier) installation costs about $225,000. It is "as accurate as it has to be" for real-time simulation and for hardware in the loop, and requires little (about 10%) maintenance. Speed depends on the programmer (usually real-time) and outputs are graphs, though "witchcraft is involved in determining reliability of answers." Advantage is a small staff, which results in low-cost operation. Disadvantages are maximum accuracy to four places and unreliability of some components, particularly servo-multipliers.

Comparison with Typical Problem

A set of four first-order differential equations with several arbitrary functions and discontinuities, representing a flat-earth missile trajectory with zero lift and angle of attack, was run on each kind of computer for comparison, with analog accuracy required in each case. Problem preparation time was about the same for analog and DDA. Preparation for the GPD using the Differential Equations Pseudo-Code Interpreter (DEPI) took two or three days as compared with two or three weeks for regular digital programming. Solutions were obtained fastest on the analog computer, with the Datatron requiring about four times as long with regular coding and 16 times as long with DEPI. A faster digital computer might reverse the analog advantage. The JPL "museum piece" DDA required by far the longest time.

The DDA should be speeded up, perhaps by parallel operation, perhaps by a method of integration which would allow larger steps. Many "classical" analog computer problems can be done faster, more cheaply, more accurately on the digital, but when it comes to simulation with hardware in the loop "the analog computer has no peer."

Lesh on Simulation of an Analog Computer

The next speaker was *Fred Lesh* (Jet Propulsion Laboratory), who described "Simulation of an Analog Computer on a Datatron 204." This work is described in JPL Memorandum No. 20-141 "DEPI: An Interpretive Digital-Computer Routine Simulating Differential-Analyzer Operations." Since copies of that report are available from JPL, we will give only a brief description of DEPI here.

Objective of the work was to devise a method of coding a digital computer which would provide much of the flexibility and ease of programming associated with analog-computer operation, and to compare the resulting system with those attributes in other computers and computer programs.

Solutions to the following missile trajectory equations were obtained using an Electronic Associates analog computer, a pre-1949 model DDA (probably ERA), and Datatron 204, using first an optimum and then a coarser integrating technique:

$$\frac{dx}{dt} = V \cos \theta$$

$$\frac{dy}{dt} = V \sin \theta$$

$$\frac{dV}{dt} = g\left[\frac{F-D}{W} - \sin \theta\right]$$

$$\frac{d\theta}{dt} = \frac{-g}{V} \cos \theta$$

$$F = K_{fv} F_v - fe\ \rho\ (y)$$

$$D = \frac{1.4}{2} \rho\ (y)\ M^2 d^2 C_D$$

$$W = W_g - w_f t \qquad (t < t_b)$$
$$= W_b \qquad (t > t_b)$$

$$C_D = 1.246 \qquad (M < 0.995)$$
$$= 2\left[\frac{0.678}{M^2} + 0.2166\right]$$
$$(0.995 < M < 5.0)$$

The DEPI Code

The DEPI code simulates the component structure of an analog computer with some minor variations. Unlike an analog-computer amplifier, which has a fixed number of inputs associated with fixed-constant multipliers, DEPI "amplifiers" accept inputs of the form $\theta_{i_1}\ \theta_{j_1} \pm \theta_{i_n}\ \theta_{j_n}$ where θ_i and θ_j are outputs of any device, and n is unlimited. Thus, DEPI amplifiers are actually amplifier-multipliers. The DEPI integrators are, like analog-computer integrators, amplifiers (i.e., amplifier-multipliers) which integrate. The DEPI function generators provide the arbitrary function $f(\theta_i)$ by using table-lookup routines with four-point interpolation. The performance of DEPI relays is identical to that of the analog-computer relays. Because of the difficulty of simulating the analog-computer networks for division and square root, and because of the ease with which these operations can be performed digitally, dividers and square-root generators are included in the DEPI component list. Since resolvers (i.e. sine and cosine generators) frequently appear as single components on an analog computer, DEPI resolvers are included. As a substitute for potentiometers, DEPI provides a memory storage for constants, and input multiplications are used to perform the potentiometer function.

The flow diagram or program for a DEPI problem has an appearance similar to the program for the same problem on an analog computer. The main difference in the structure of the programs is that in the analog program a line is drawn from component A to component B to indicate that the output of a component A is used as the input to component B. In the DEPI program, this relationship is indicated by writing the component number of component A on a short line entering component B.

The fact that the simultaneity of operation of analog components cannot possibly be duplicated on currently existing digital computers constitutes a significant structural difference which necessitates the establishment of a certain order in the operation of the components. Violation of restrictions imposed by the necessity for serial servicing causes a re-

sponse analogous to a time delay in the part of the circuit where the violation occurs.

Because the detailed problem instructions to the computer are in terms of patch words instead of machine code words, the machine must translate the patch words into machine language before it can operate. This can be accomplished in two entirely different ways. One is to perform the entire translation before any computing is done, making a complete code which is then used throughout the computation. The second way is to examine each pseudo-code word in turn, performing the computing and translating simultaneously. The first method, sometimes called "compiling," gives faster operation but is much more difficult to code and make flexible. The second method, called "interpreting," is comparatively simple to code and can easily be made extremely flexible, but is expensive in operating time. The latter method is the one used in DEPI.

Runge-Kutta integration was used. The simple integration schemes have the distinct advantage of being easy to code, but have the disadvantage of requiring extremely small mesh size for the sake of accuracy; for this reason, the simpler systems are frequently slower than the Runge-Kutta scheme.

Time Comparison

The standard digital-computer trajectory computation required eight minutes; the coarse-integration procedure, two minutes; the DEPI solution, four minutes; the analog solution, 0.5 minute; and the DDA three minutes, thirty minutes, and five hours, for three different scalings.

Accuracy Comparison

The analog computer retains about 98.5 to 98% accuracy, both DEPI and the coarsely-integrated digital computer are still more accurate, and the thirty-minute DDA run has a final accuracy of about 80%. Results from a DDA should be reproducible like those from a GPD computer. The excess variation is probably due to the manner in which atmospheric pressure was simulated, using an optical curve follower.

The rather large ratio between DEPI calculating time and standard-program calculating time could probably be reduced almost to unity by the use of compiling, rather than interpretive, techniques. It would be much more difficult to code such a compiling routine while maintaining the flexibility of an interpretive scheme; however, this routine could be developed and would yield a system in which problem presentation and alteration would be relatively simple, and the computing time would be shorter than for DEPI.

Selfridge on Simulation of a DDA by a GPD

The third speaker of the afternoon was *Dr. Roy Selfridge* (Naval Ordnance Test Station, China Lake, Calif.), who described simulation of a DDA on an IBM 704.

Whenever one is faced with the problem of solving differential equations on a digital computer, there are several compromises to consider. A specific program can be tailored for the equation, which yields the fastest and most efficient solution, but may take months to program; or a specific program can be tailored to the equation using available codes. This will decrease the accuracy or speed of computation, but can be constructed much more quickly. Or a general-purpose differential equation-solving routine may be used. This is the fastest to prepare, but probably the least accurate.

Analog computers and DDA's have several desirable features, not the least being ease of coding, or problem layout. One therefore thinks of constructing a code for a general-purpose machine which will allow the use of analog or DDA techniques. Within certain limits this has been done in several places. The end results, in the sense of which machine does best, depend on the organization which controls the machines, and the complexity of the problem.

A tremendous advantage of the digital machine over the analog is its repeatability, in that two runs will coincide (or differ considerably due to machine error) even on a very sensitive problem. Even the most recent analog machines will not give complete repeatability on sensitive problems.

The DDA and analog machine possess the advantage in cost, by a factor of five to one, or more.

Even with present-day patchboards for an analog machine, the digital is easier to prepare for a problem which has been done before. A stack of cards or a tape is easier to load than an analog machine is to set up. The digital machine will do certain operations which the DDA or analog cannot, and can solve larger problems more accurately (at a cost in operating time).

Experience to date seems to indicate a choice based on several factors. For a one-shot job, use a digital machine with an analog simulator. For high accuracy there is no choice but the general-purpose digital machine. If the problem requires information feedback through the originator, pick a DDA or analog machine and get the originator into the act. Although a general-purpose machine can be changed around as easily as an analog or a DDA, management is horrified to see someone sitting in front of such a machine and "playing"—at $200 an hour!

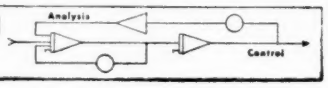
At least one program has been written to simulate a DDA in every respect. This was a rather slow procedure, but the purpose was not to solve differential equations so much as to test a particular application of a particular DDA. The present DDA simulation programs only reproduce the operational end of the DDA; the inner workings are quite different. Again there is a choice to be made; flexibility must be weighed against speed and accuracy of computation. This is a function of the type of integration, with the more esoteric forms yielding high accuracy or high speed, but low flexibility, and vice versa for the very simple forms.

Adams on Combined Simulation

The next speaker was *Bob Adams* (Ramo-Wooldridge), who described the Remington-Rand 1103A digital computer, the Electronic Associates analog computer, and the Epsco Addaverter, all of which they are using in their combined simulation. As this equipment is familiar to readers of this *Newsletter** and *I&A*, Bob's talk will not be abstracted here; however, some of his comments are of interest.

Bob said that they haven't used their Addaverter long enough to quote reliable numbers, but it seems that both the digital-to-analog and analog-to-digital conversions are accurate to 0.15%, or 20 millivolts, whichever is larger. That is the accuracy for a single conversion, the

*See *Newsletter* in February '56 *I&A* and article "Combined Analog and Digital Systems—Why, When, and How" in June '57 *I&A*.



average accuracy for a conversion being two millivolts. So if you are feeding an integrator, the drift would be a function of the two, rather than the 20, millivolt figure, as most of the 20 millivolts is attributable to noise.

A conversion from analog to digital requires from 125 to about 225 microseconds, and is adjustable with a pot. A digital-to-analog conversion requires 125 microseconds to settle out to 0.1%, this time being a function of a low-pass filter in the output.

Bob says they have no reason to feel that the Addaverter is not as reliable as other electronic devices of similar complexity.

In answer to a question by *Lou Ortega* (Convair-Astronautics, San Diego, Calif.), Bob said that they have 15 channels operating in each direction; that they have been doing serious missile simulations for about two months; and that they have accepted the Addaverter. Bob further stated that they plan to use the Addaverter for processing telemetered data. Tapes with PDM* data will be played back on the tape machine in their analog facility and fed through the Addaverter to the digital computer, which will decommutate and order the data for them.

In answer to questions by *Walter Varner* (Convair-Astronautics, San Diego, Calif.), Bob said that they do not have, but wish they had, sample-and-hold circuits; that because they do not, their 0.1% accuracy holds up to only about five cycles; and that they have not decided whether they will add such circuits or have Epsco do it.

Dov Abramis (Convair-Pomona, Calif.) commented that the Multiplier Committee of the Western Simulation Council has devised a method of evaluating multipliers using the Addaverter, and that thanks to Convair-Astronautics some interesting results have already been achieved and will be published.

Schumate on Combined Analog and Digital Simulations

Mike Schumate (Ramo-Wooldridge) was the final speaker on the program. Because Mike described the simulation which was later demonstrated to the group, a somewhat more detailed abstract of his talk follows.

Mike first showed a block diagram of the analog part of the simulation. The guidance command from the digital computer comes over through one channel of the Addaverter and is fed to the analog missile-autopilot simulation. The autopilot commands the missile control surface, and the results are fed into the missile translation and rotation equations. The output of the translation equations, the net forces acting along missile axes, are fed through a rotation matrix, which transforms them to an inertial geocentric non-rotating-earth system. The outputs of the rotation equations are used to compute Euler angles which force the rotation matrix and the autopilot.

Mike next projected a block diagram of the digital computer portion of the simulation which showed the summation of the forces coming from the analog computer, divided by the mass. The force of gravity is calculated very accurately and added to the other forces to obtain the absolute missile acceleration, which is then integrated twice to obtain velocity and position. The velocity and position of the missile are then put through a rotation matrix which relates the inertial axes to the launcher axes, a geo-fixed coordinate system. Guidance is then computed, based upon these coordinates, and guidance commands are sent to the analog computer via the Addaverter.

Discrete signals like the engine shut-off command are computed by the guidance simulation in the digital computer and transmitted to the analog missile simulation via separate Addaverter channels.

Bill Kindle (EAI Computation Center, El Segundo, Calif.) asked if R-W had run any error analyses to determine the effect of analog errors on the simulation. "Not as such," Mike said. "We have been flying this thing by the seat of our pants. We try to pick our integration formulas so that they will not introduce any spurious resonances or other undesirable effects. The only way we could get an absolute indication of accuracy would be to fly a simulated missile open-looped (without guidance) so that we could get a feel for repeatability. If guidance were in, it would wash out any errors and force the missile to perform as it should."

Irwin Pfeffer (Ramo-Woolridge) explained, "Errors introduced by both the analog computer and the Addaverter have the same appearance as hardware errors in the missile itself; but the expected accuracy of the hardware in the missile is about one order of magnitude worse than the analog or Addaverter errors which may be introduced. As any guidance system capable of working at all must be able to wash out errors introduced by the hardware, which may be from one to five percent, the 0.1 to 0.2% errors of the simulation equipment will certainly be washed out."

George Forbes (Litton Industries) asked if they had considered using a DDA in the loop. "No, primarily because we don't have one. However, it's something that should be considered," Mike replied.

Fred Williams (Hughes Aircraft, Culver City, Calif.) asked, "Have you used a digital computer subroutine as a function generator?"

"We intend to, but the functions with which we have dealt to date have not been that complicated."

Paul Williams (Northrop Aircraft, Hawthorne, Calif.) asked about using the digital computer for multiplications in an otherwise analog setup.

"We have quite a supply of electronic multipliers in our analog computer lab and have not found it necessary to use the digital computer for anything as simple as multiplication."

When asked if they had solved any problems in the combined simulation that had been formerly done on the digital alone, Mike replied that they had, and that they got very good agreement.

Asked about solution time, Mike said the digital computer gave quicker solutions on simple problems, but that their present problems would take longer.

When asked about putting real hardware in the loop, he said there is a possibility that they will.

Walter Varner wanted to know how long it took to check out the demonstration which was to be given. Amid much laughter Mike replied, "The checkout of this particular simulation involves a count-down list of a page and two-thirds, and takes about 20 minutes. Starting from scratch we could probably put the simulation on and have it running in half an hour, but this is an extremely simple problem involving only one board of analog computing equipment. To be perfectly frank, we do have equipment difficulties, so half an hour is optimistic. When we came in this morning the thing worked the first time, but I might add that this

*That's what the man said!

is the first time it has worked the first time! We attribute our trouble to the newness of the Addaverter more than to anything else. However, the 1103 is not interrupting properly. Interrupt signals sometimes send the computer off on a wild-goose chase. Once we get the equipment reliable, I don't think that we will have any problems worse than those involved in putting a problem on the analog computer alone."

When asked about output, Mike said, "Some of it is stored and later printed out. For monitoring during the flight we have the digital computer send three pieces of information through the Addaverter—position error, velocity error, and acceleration error. These are then plotted."

Dick Klaus (Convair-Astronautics) asked whether they had done any read-around with the Addaverter—that is, present a number, have it converted, and then convert it back to the number—to check the Addaverter itself.

Bob Adams remarked that they had books of that sort of thing, to which Dick replied that he would like to see them.

There followed a break, with refreshments, and then the 111 people at the meeting were divided into two groups and taken to the computing facility. The simulation which had been described seemed to operate satisfactorily for several flights but then became erratic.

Information (Without Theory)

Dov Abramis reports that the 18 technical papers presented at the Simulation Councils, Inc. national meeting in Washington in December were of such high calibre and unusual interest that, contrary to original plans, they will be made available as a separate publication, *provided* enough money is received in advance to cover the cost. These papers will *not* appear in the ACM publication, so please send (or have your library send) $3 in cash, check, or money order to your local Council Secretary. If you are not affiliated with a local Council payment should be addressed to Suzette McLeod, Treasurer, Simulation Council, Inc., 8434 La Jolla Shores Drive, La Jolla, California.

A feature of the American Management Association's Electronic Conference and Exhibit in New York this month was a closed-circuit telecast showing how parts of GE's plant operation—which includes 17 miles of overhead conveyors—are "simulated" on a mathematical model. The model, programmed on a large-scale computer, figures variables of location, output, load, to achieve optimum production schedules without interrupting line operation, so that component parts can be brought to the assembly line in the most efficient way possible.

Computer Events

IRE National Convention

Dates: 24-27 March 1958

Place: Coliseum and Waldorf-Astoria Hotel New York, N. Y. On March 25 there will be symposia on "Electronics in Space" and "Electronics Systems in Industry."

DDA Council

Date: Monday, 5 May 1958

Place: Los Angeles, California Details as to place and subject will be announced later. For information write Stan Rogers at 3023 Alcott Street, San Diego, Calif.

Western Joint Computer Conference

Dates: 6-9 May 1958

Place: Ambassador Hotel Los Angeles, California

Subject: "Contrasts in Computers" Sponsored by IRE, ACM, and AIEE

Association for Computing Machinery—Annual Meeting

Dates: 11-13 June 1958

Place: University of Illinois, Urbana, Ill.

1958 National Simulation Conference

Dates: 23-25 October 1958

Place: Dallas, Texas The conference will be sponsored by the IRE Professional Group on Electronic Computers and the Dallas Section of the IRE. For information write Louis B. Wadel at 3905 Centenary Drive, Dallas 25, Texas.

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- unaffected by any commercial chemical
- stress relieved for negligible shrinkage
- continuous service temperature of 250°C—intermittent to 300°C

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*Teflon—DuPont trade name for Tetrafluoroethylene resin

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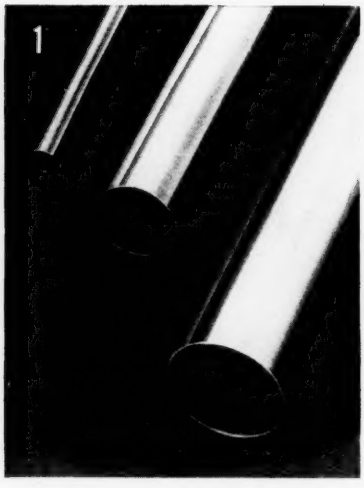

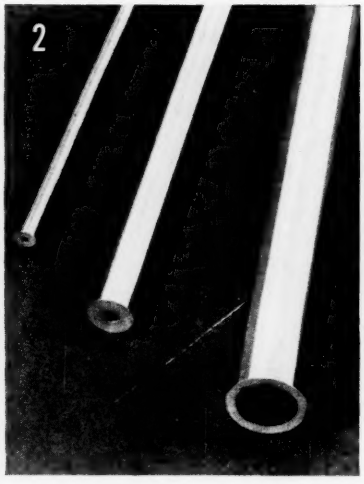

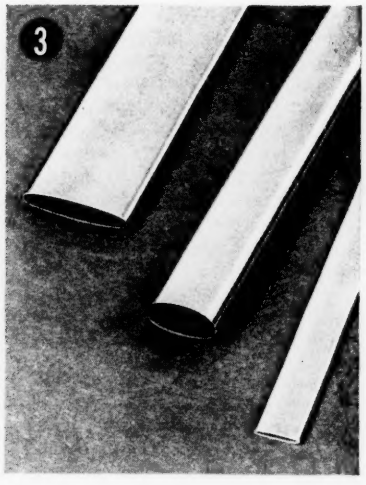

Take advantage of Superior's unequalled variety of instrument tubing. Now you can select tubing from a wide choice of analyses (over 120), sizes, shapes, and mechanical properties. All tubing is produced to extremely close tolerances, finished with bright, clean, uniform surfaces.

1 Mechanical Tubing—Instrument Line

Produced in both seamless and Weldrawn forms, generally to meet such requirements as special OD-ID or ID-wall limits; special analysis or heat selection; controlled mechanical properties; and special finishes. Extra-long straight or coiled lengths or specific cut or multiple lengths. Cut and multiple lengths up to 39 ft. maximum. Coil lengths up to 500 ft., depending on material and size desired.

2 Pressure and Super Pressure Tubing

Made from specially selected raw materials which have had inside surfaces conditioned to remove fissures and other defects. Produced in stainless, carbon and alloy steels to carry pressures as high as 100,000 psi. Finished tubing must meet special inspection standards. Super pressure tubing is available in single wall, which will give long reliable service at lower working pressures, or in composite wall to withstand higher pressures. Used in hydrogenation process equipment and high pressure autoclaves.

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Superior's wide range of alloys and sizes makes it possible to satisfy any set of service conditions—such as high strength, low hysteresis, corrosion resistance, etc.—for Bourdon tubing in indicating and recording instruments. Many different analyses to choose from, including Ni-Span C. Helix and spiral as well as "C" tube elements are fabricated from the many analyses which Superior offers. Smooth, clean surfaces, close dimension control, freedom from decarburization, accurate shaping and cleanliness, all combine to produce Bourdon tubing of unexcelled quality.

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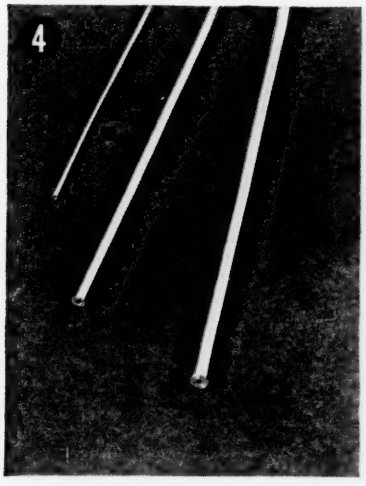
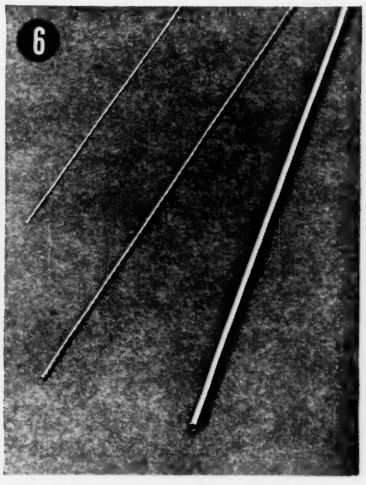
Superior capillary tubing is used for transmitting temperature and pressure impulses from the source to a recording or indicating instrument. Any outside diameter can be produced up to and including $^{3}/_{16}$ in. OD. IDs range from .004 in. minimum to .080 in. maximum. Has smooth ID, extreme ID uniformity, excellent corrosion resistance, and is easy to weld, braze or solder. Types 304, 316, 321, 347 and 446 stainless, Monel, Inconel, nickel

produces 6 types of tubing for any instrument

RANGE OF SIZES AND ALLOYS





and carbon are recommended analyses. Can be produced in straight lengths or long coils.

5 Large OD Thin Wall Tubing

In sizes to $2\frac{1}{2}$ in. OD, large diameter thin-wall tubing is available in Types 304, 321 and 347 stainless steel. In other stainless analyses the limit is $1\frac{1}{8}$ in. OD. It is also available in 16 additional ferrous and nonferrous analyses. Is easily fabricated and has been used in such applications as bellows, flexible metal hose, and instrument casings. Available in both seamless and Weldrawn® (welded and drawn) forms. In a variety of tempers.

6 Needle Tubing

For years Superior has made the finest stainless steel hypodermic needle tubing available. Originally developed to provide free, sterile passage for fluids, this tubing is now used for a wide variety of industrial applications such as tips and fountain parts in continuous inking equipment, nozzles for the application of lubricants, for dispensing minute, accurate quantities of liquids in microchemical work. The high strength, stiffness and strict dimensional tolerances of this tubing make it ideal for instrument application.

Your nearest Superior warehouse distributor can help you with any tubing problems—may often offer money-saving recommendations. If you do not know the name of the Superior warehouse distributor for your area, tell us to furnish you with it.

For a free copy of Bulletin 40—"A Guide to the Selection and Application of Superior Tubing"—write Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

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All analyses .010 in. to $\frac{3}{4}$ in. OD—certain analyses in light walls up to $2\frac{1}{4}$ in. OD

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new instruments

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computing and data processing

COMPUTER LANGUAGE TRANSLATOR

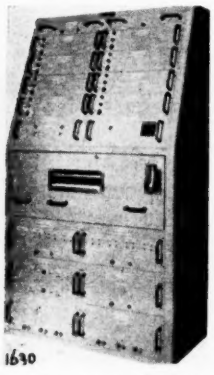
New Model ZA-100 makes possible rapid interchange of data between different types of electronic computers and data processing equipment. Translation operations requiring hours using punched card methods now take seconds: mag-tape format conversion, also punched cards or punched paper tape to magnetic tape; also magnetic tape to punched cards, paper tape or line printer. One translator system can perform any one of several input-output requirements.—*Electronic Engineering Co. of Calif.*, 1601 *Chestnut, Santa Ana, Calif.*

1831

For more information circle **303** on inquiry card.

RAPID MULTIPLE RECORDER

New Model 260 produces up to eight 11"-wide records, features transient response up to 3,000 cps; uses electrosensitive paper requiring no processing and reproducible by standard duplicating methods. Electronic writing method obviates overshoots, damping and ink splatter. Recording accuracy is unaffected by line voltage variations and paper stretch because scales (0-100) and time marks (1, 0.1 or 1/60 sec) are recorded simultaneously with input signals. All eight channels can be operated simultaneously for full 11" paper width and yet maintain better than 1% accuracy. Each channel trace can be coded for identification by varying width and darkness of traces.—*Consolidated Avionics Corp., Westbury, N. Y.*


1830

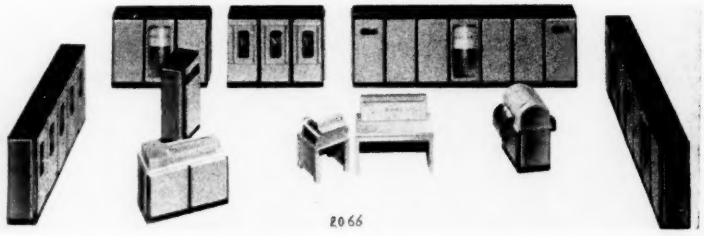
For more information circle **301** on inquiry card.

MAGNETIC CORE MEMORY

New Model CB-602-1000 Magnetic Core Buffer Storage Unit, capacity 1000 bits, stores high-speed (above 20 kc) data, uses highly reliable magnetic storage elements (shift registers), so that power is consumed only during read-in and read-out command times. Storage is retained indefinitely—even in event of power failure. Construction is modular. Shift registers can be connected in various groups to achieve a total static capacity of 1000 bits or in various combinations for special input and output capacities; e.g. up to 25 series words of 40 parallel bits, 50 of 20, etc. Further versatility of data output can be realized by external connection of drive signals so that shift registers can be advanced in groups simultaneously, or each shift register can be advanced independently, or advanced in any combination with other registers.—*Epsco, Inc., Components Div., 108 Cunnington St., Boston 15, Mass.*

For more information circle **302** on inquiry card.

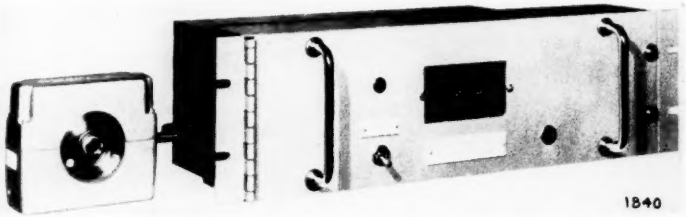
ELECTRONIC DATA PROCESSING SYSTEMS


2066

New 304 Series systems are said to offer "important advantages which have not previously been available in the area of office automation." Both punched paper tape and punched cards can be produced from NCR accounting, bookkeeping and adding machines, cash registers, etc. Tapes and cards created automatically can later be fed directly into 304 System for automatic processing.—*National Cash Register Co., Dayton, Ohio.*

For more information circle **304** on inquiry card.

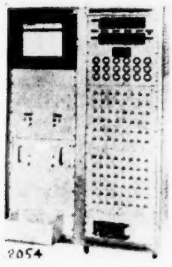
DIGITAL SHAFT POSITION ENCODERS


1840

New Digital Position Indicating Equipments provide a continuous indication of a shaft position (rotating at speeds to 120 rpm) on either a digital display for visual indication or on various recording media, or both.—*G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena, Calif.*

For more information circle **305** on inquiry card.

MULTICHANNEL PLOTTER



New 95-channel Model 221 high-speed autographic plotter for test use plots 20 channels per second with input from strain gages, thermocouples, etc. Three ranges available: ±2,000, ±5,000, and ±10,000 microinches across 5" vertical strain chart. Chart paper is 11" wide Teledeltos type with four graphs across chart.—*Gilmore Industries, Inc.*, 5713 *Euclid Ave., Cleveland 3, Ohio.*

For more information circle **306** on inquiry card.

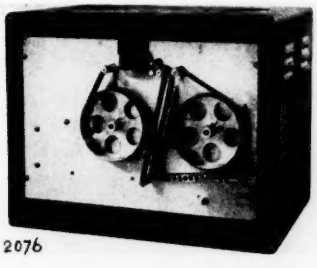
PERFORATED TAPE READER

New Dykor handles paper tape strips or reels at speeds of up to 750 characters per second with less than 5-millisecond start or stop time. At 300 ch sec it stops in space following stop character; for 750 ch sec a 2-ch stop space is recommended. Among other features: all standard 5-, 6-, 7- or 8-level tapes (plus sprocket hole) are handled; ½", ⅞" or 1" tape can be used interchangeably; complete remote control of forward, reverse, stop and speed change; bidirectional operation of both reels and strips.—*Digitronics Corp., Albertson Ave., Albertson, L. I., N. Y.*

For more information circle **307** on inquiry card.

RAPID-ACCESS MEMORY

New Model 3270 MINIRAM (Miniature Random Access Memory) stores up to 10 million bits with an average access time of less than 0.5 sec; can be programmed to return to center of the tape after each "look-up" or can be stopped at end-of-tape or any point desired. For applications requir-

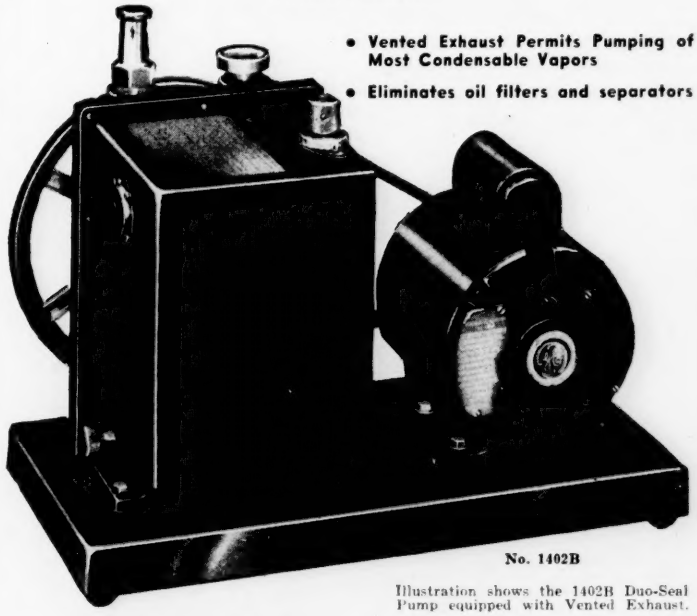


2076

Large Capacity—High Vacuum
Welch DUO-SEAL VACUUM PUMP
TWO-STAGE CONSTRUCTION

with VENTED-EXHAUST

PATENT PENDING



- **Vented Exhaust Permits Pumping of Most Condensable Vapors**
- **Eliminates oil filters and separators**

No. 1402B

Illustration shows the 1402B Duo-Seal Pump equipped with Vented Exhaust.

GUARANTEED VACUUM—with vent closed 0.1 micron. When the vent is open, only slightly higher ultimate pressures result—usually in the range of 1 micron.
FREE AIR CAPACITY—140 liters/minute (5 cubic feet)

PUMPING SPEED		
At	Vented Exhaust Closed	Vented Exhaust Open
1000 microns	110 L/M	100 L/M
100 microns	100 L/M	92 L/M
10 microns	92 L/M	68 L/M
1 micron	76 L/M	28 L/M

1402B. DUO-SEAL VACUUM PUMP, Motor Driven.
For 115 Volts, 60 Cycles, A. C. **Each, $310.00**

1402C. DUO-SEAL VACUUM PUMP, Motor Driven.
For 230 Volts, 60 Cycles, A.C. **Each, $310.00**
For attached Belt Guard, add $17.50 to above prices.

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For 115 Volts, D.C. **Each, $388.50**
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With pulley, but without motor, belt or base.
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This C-Mar Series 5000 area meter differs from conventional "rotameters" in many important ways. Area of opening for flow is varied by an accurately cut and tapered *orifice*, rather than a tapered *tube*. Result: simplified design, easier installation and maintenance, and a number of operating advantages *at no increase in cost*.

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New Series 5000 TAPOR-FLO Meter with bottle safety shield. Meter has only 12 basic parts, with all identical parts completely interchangeable.

Write for Bulletin 5010. Get full specifications on this completely new meter, including O-ring seals and versatile end fitting design for vertical or side pipe connection. Also covers OPTIONS, such as materials, magnetic read-out, transmission, and tripod mounting.

C-MAR Corporation 35 Euclid Ave., Manasquan, N. J. Phone: CAstle 3-0515

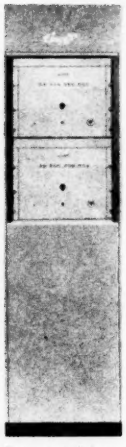
TAPOR-FLO INSTRUMENTATION • *U. S. AND FOREIGN PATENTS PENDING

For more information circle **85** on inquiry card.

ing storage of more than 10 million bits, MINIRAM transport units can be added to form a bank storing an enormous amount of digital data. Further economy can be realized by utilizing a common programming circuit for a number of transport units. —*Potter Instrument Co., Sunnyside Blvd., Plainview, L. I., N. Y.*

For more information circle **308** on inquiry card.

AN-DIG COMPUTING LINK

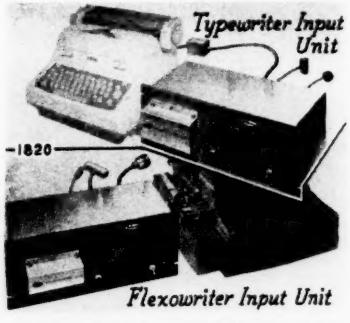


New Model B Addaverter is a versatile low-cost analog-digital computer linkage which provides two channels of information flow between virtually any analog and digital computers; permits (1) combined an-dig simulation, (2) combined an-dig computation, (3) real time digital control of processes, (4) analysis of operating prototypes, (5) digital generation of analog functions.—*Epsco, Inc., 588 Commonwealth Ave., Boston* 15, *Mass.*

For more information circle **309** on inquiry card.

INPUT UNITS

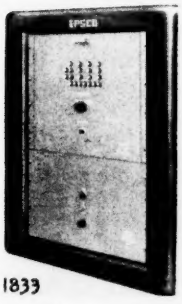
New Model AV98 (capacity 98 bits) and Model AV49 (capacity 48 bits) Typewriter Input Units oper-



ate with IBM Output Writer or other solenoid-operated electric typewriter directly; include a patching program plug to determine format of typewritten copy. ★New Model NV56 (capacity 56 bits) accepts digital input data, programs desired format, and scans digital information into a Flexowriter-Tape Punch combination modified to permit input from an external source; can provide any code (8 channels max) and permits changes in format to be made readily by means of a patching program plug.—*Coleman Engineering Co., Inc., 6040 N. Jefferson Blvd., Los Angeles* 16, *Calif.*

For more information circle **310** on inquiry card.

HIGH SPEED VOLTAGE-TO-DIGITAL CONVERTER



New Model B-617 Datrac converts input voltages to four binary-coded decimal digits at rate of 3700 per second, with an accuracy of 0.05% of reading $\pm\frac{1}{2}$ the least significant binary digit. Standard full-scale input ranges of ±10, ±100 and ±1000 are provided with range switching accomplished by application of an external trigger pulse. Much higher conversion rates can be obtained if electronic input range switching is not required.—*Epsco, Inc.*, 588 *Commonwealth Ave., Boston* 15, *Mass.*

For more information circle 311 on inquiry card.

HIGH SPEED PRINTER

New Series 56-24 prints on 4"-wide single, multiple-carbon or heat-transfer type forms; provides 24 printing positions in each line—and any one of 56 (or 64) characters can print in each position; prints up to 600 lines per minute for alphanumeric printing or 1200 for numeric printing; can be used with a decoder to print directly from a computer or (with proper accessories) from magnetic tape or punched cards; can be used also to print out real-time data from automatized manufacturing processes.—*ANelex Corp.*, 150 *Causeway St., Boston* 14, *Mass.*

For more information circle 312 on inquiry card.

TYPEWRITER-COMPUTER

New low-cost 632 Electronic Typing Calculator, designed primarily for order and invoice preparation,

can be operated by a typist with only a few minutes of instruction; comprises an IBM Electric Typewriter, a 10-key companion keyboard, a magnetic core memory within computer unit, and a program reading device. —*Int'l Business Machines Corp.*, 590 *Madison Ave., New York* 22, *N. Y.*

For more information circle 313 on inquiry card.

Find out what's going on—and do something about it! with

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COC

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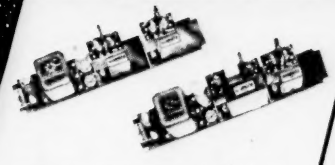
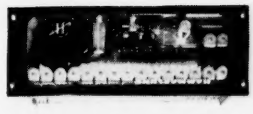
Start right now to enjoy the economies and operating efficiencies of remote supervision—see what's going on, and control it—it costs less than you think with Hammarlund COC equipment

Hammarlund COC provides low-cost, practical remote monitoring and control of systems and processes. Hammarlund systems are made up of off-the-shelf assemblies that have been proved in thousands of installations. Every component, every assembly is designed and manufactured to do the job efficiently, dependably. Hammarlund COC utilizes ordinary telephone lines, or radio links.



Tone signalling equipment permitting 22 to 25 various functions on a single telephone pair



Pulse signalling equipment permitting up to ten functions on a single audio tone frequency

Test meter permits maintenance by non-technical personnel

Alarm system provides POWER OFF alarm. Simple, inexpensive. Battery-operated, completely transistorized

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460 W. 34th St., New York 1, New York

Established 1910

For more information circle **86** on inquiry card.

THIS IS
ZIPPERTUBING
...a method of making custom electronic cables in seconds.. at a fraction of the cost!

Now available in Vinyl, New Stretch Vinyl, Teflon, Nylon, Mylar, Neoprene.

Major Advantages

1. Cables are made by you, on the spot, as needed, without machinery. Production delays eliminated.
2. New stretch compound provides tighter jacketing.
3. Highly abrasion-resistant. Temperature range, —90°F to 450°F.
4. Eliminates expensive lacing or tying of conductors.
5. Provides re-accessibility to conductors, or can be permanently sealed.
6. New method permits cable termination with any type of connector.
7. Sizes from ¼" ID—continuous lengths to 1000 ft.
8. New metal laminations for shielded or co-axial cable construction.
9. Perforated type or molded "Ys" and "Ts" simplify branchouts.

Important

If you design or work with electronic cables, it will pay you to try ZIPPERTUBING. Field representatives are nearby—or send for free sample and technical literature.

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TWX LA 840

For more information circle **88** on inquiry card.

process analyzers, monitors, controllers

AUTOMATIC RATE METER

New Automatic Rate Meter monitors any test or process variable (such as temperature) which increases at a constant rate; automatically indicates correct value for this variable at any moment after start of process or test. Operator simply adjusts flow of energy or material so that his indicator (such as thermometer) reading matches reading on Automatic Rate Meter. It enables one operator to simultaneously conduct a number of processes or tests started at different times.—*Apex Scientific Co., 59 Donna Maria Way, Orinda, Calif.*

For more information circle **314** on inquiry card.

COMBUSTIBLE GAS ANALYZER

New Model F provides continuous or intermittent sampling and measurement of combustible gases and vapors in mixtures with air at normal or high temperatures; features an extremely long life filament, and remote analyzing head with explosion-proof housing which operates at high temperatures and analyzes hot samples in the area of their occurrence without danger of combustible-vapor condensation.—*Mine Safety Appliances Co., 201 N. Braddock St., Pittsburgh 8, Pa.*

For more information circle **315** on inquiry card.

PNEUMATIC CONTROL RELAYS

New Types VRR-Ratio and VMR-Multiplying pneumatic relays produce an output according to an easily adjustable proportional relationship to input; utilize maker's null-balance-vector principle for accuracy, sensitivity, compactness, and interchangeability. Range of ratios of a standard VRR relay is 0 to 2:1; 3 to 5 psig input and output. Standard VMR Relays have a range of ratios of 0 to 3.1; pressure ratings 40 psig max input, 33 psig max output. Optional range of ratios: 0 to 6:1 and 0.7:1 for VRR and 0 to 9:1 and 0 to 1:1 for VMR.—*Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.*

For more information circle **316** on inquiry card.

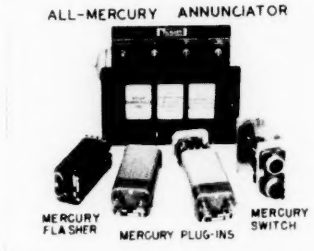
THERMAL CONDUCTIVITY GAS ANALYZER

New low-cost Model 7C, for continuous monitoring of one constituent in a wide variety of combination gases, weighs about 50 lb and measures 18⅜ x 15 x 11 ⅛". It utilizes ultrasensitive thermal-conductivity filaments; has a cell response time of 30 sec for 95% of change at sample flow rates of 250 cc/min. Single or multiple ranges from zero to 0.5 and zero to 100% full-scale; wide variety of high-sensitivity detector filaments (Kovar, tungsten, nickel, rhodium, etc.); glass-coated thermistors for corrosive sampling; sampling systems for both corrosive and non-corrosive streams; and high stability (±1% for ±15% change in input voltage).—*Beckman Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.*

For more information circle **317** on inquiry card.

ANNUNCIATOR SYSTEMS

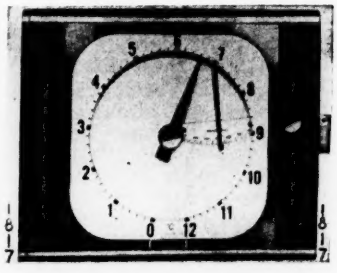
New complete line of annunciators utilizes 100% mercury relay contactors for efficient and high current interrupting characteristics, quietness, and freedom from explosion hazards. Wide choice of circuitry, including operational sequences heretofore requiring complex relaying components.—*Tigerman Engineering Co., 4332 N. Western Ave., Chicago 18, Ill.*



For more information circle **318** on inquiry card.

INDICATING POTENTIOMETER

New indicating version of Dynamaster self-balancing potentiometer or bridge, has same 32"-long scale

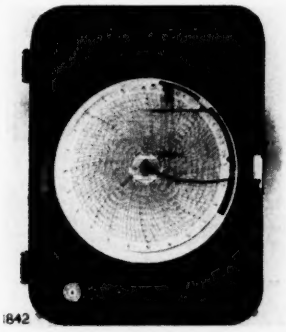


and same pointer as standard round-chart recording Dynamaster and is mounted in a standard case; is also offered in electric control models, in on-off, two-position, three-position, floating, proportional, and current-input modes of control.—*The Bristol Co., Waterbury 20, Conn.*

For more information circle **319** on inquiry card.

MULTIPLE RECORDER

New electronic recorder can receive and record outputs from as many as four remote ring-balance-meter-operated slide wires. These outputs in-



1842

clude temperature- and pressure-compensated fluid flow readings, also fluid density, liquid level, etc. Recorder is available as an ac bridge, dc potentiometer or dc voltmeter. Integrator is included in flow receivers. —*Hagan Chemicals & Controls, Inc., Hagan Bldg., Pittsburgh 30, Pa.*

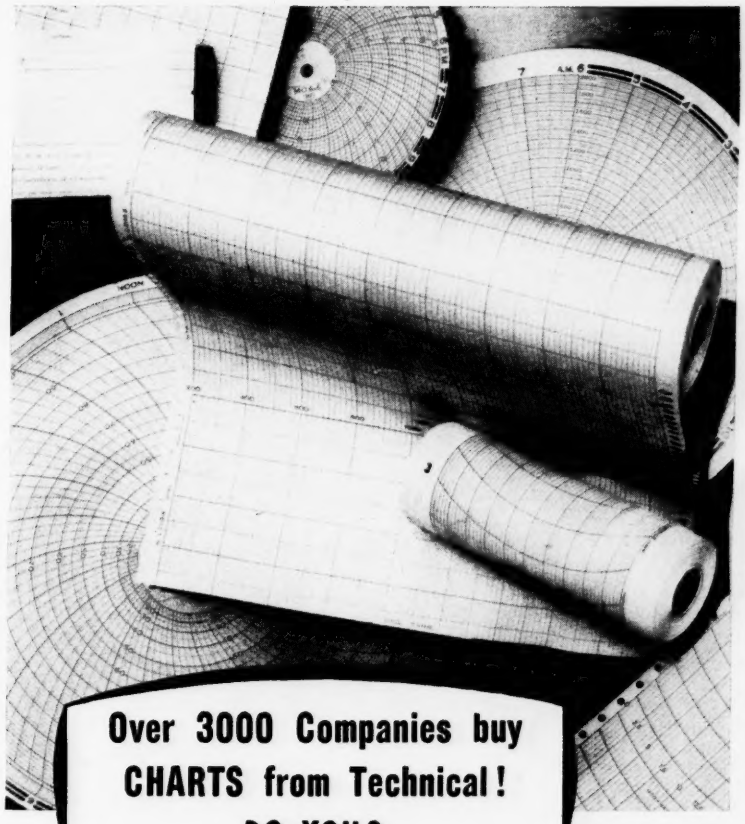
For more information circle **320** on inquiry card.

PRODUCTION DATA RECORDER

New Production Data Recorder is designed to be located in factory manufacturing or assembly depart-

1823

ments where it will accept a variety of information, select and combine pertinent data and produce a record on punched paper tape, punched cards or magnetic tape immediately available for machine tabulating or computing. Standard output unit is a paper tape punch producing 8-level punched tape at 10 characters per second. (Special configurations use punched cards or magnetic tape as output.) A number of accessory "building-block" units provide differ-



Over 3000 Companies buy CHARTS from Technical! DO YOU?

Saves your time... Holds down costs

Obvious economies result from "single source" purchasing of *all* recording charts. Why write a dozen purchase orders to different suppliers when *one* to Technical does the job? Fewer headaches, too, in "following through."

ACCEPTANCE by America's leading industrial firms attests to Technical's fine quality — achieved through years of specialization in one product.

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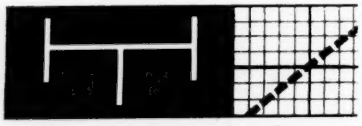
STAEBLER & BAKER, INC. Clayton, N. Y. — TECHNICAL CHARTS, INC. Buffalo, N. Y.

For more information circle **89** on inquiry card.

P·B·X A completely new ceramic cement that solves the problem of electrical insulation at extremely high temperature. This new material offers the following properties: • High resistivity • Excellent thermal shock • Superior bond strength • Air dries rapidly • Cures at low temperature • Withstands high "G"-loadings • Severe vibrations.

For further information write to:



HIGH TEMPERATURE INSTRUMENTS CORPORATION

#1 Highland Avenue, Bala-Cynwyd, Pa.

For more information circle **90** on inquiry card.

NEW INSTRUMENTS

ent levels of information in varying forms and enable grouping many recorders into a complete production data processing system.—*Control Data Corp., 501 Park Ave., Minneapolis 15, Minn.*

For more information circle **321** on inquiry card.

MONITOR CONSOLES

New MC-2 is said to be ideally suited for "quick look" editing and monitoring of accumulated PW tele-

metered data. Control panel of miniature toggle switches permits selecting any of 86 data channels, or any specific grouping of these channels, for bar-graphing display on a 17" screen.—*Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.*

For more information circle **322** on inquiry card.

SCHEDULING CALENDAR

New Sked-U-Cal 25-year reminder-type wall calendar with changeable monthly calendar cards having big

date spaces for erasable notes, is a practical and permanent working tool rather than a temporary paper medium. Basic copyrighted feature is contained in monthly name-cards, keyed (by letters) to correct monthly calendars for the next 25 years. Users can start with any month and always have the latest full year calendar, and more. At end of month, user wipes card clean in seconds and changes for next later card. At year-end, next year's calendar is already in place. —*L. D. Blehart Co., Lucas Bldg., 10 Fiske Pl., Mt. Vernon, N. Y.*

For more information circle **323** on inquiry card.

Telemeter ANY VARIABLE from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

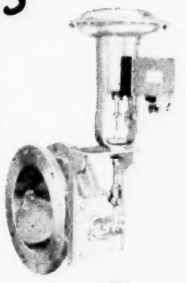
Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

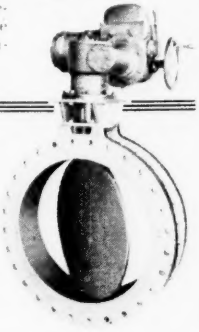
For more information circle **91** on inquiry card.

AUTOMATED FOR CONTROLLED FLOW

ROCKWELL *BUTTERFLY VALVES*

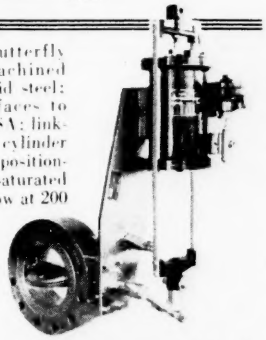


Standard butterfly valve with simplified bracket and linkage to air diaphragm operator and valve disc positioner; provides maximum adjustment, minimizes friction, eliminates backlash, chatter and hunting, reduces power requirement in close control applications.



Standard heavy duty butterfly valve with Limitorque electric motor, declutching mechanism and handwheel for air, gases, water or other fluids.

Threaded butterfly valve with "Robotair" diaphragm operator.



Wafer butterfly valve machined from solid steel; flange faces to 300# ASA; linked to air cylinder and disc positioner; for saturated steam flow at 200 psig.

Rockwell valves for gases, liquids or solids are furnished with any approved operators and control devices to provide automatic proximate or remote operation. Write for catalog.

W. S. ROCKWELL COMPANY
2128 ELIOT STREET
FAIRFIELD, CONN.

For more information circle **92** on inquiry card.

temperature

H-P H-T THERMOCOUPLES

New leak-proof high-pressure thermocouple, for use in pressure systems to 80,000 psi and temperatures to

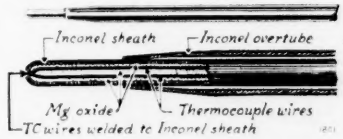
1804

1000 F, is built into a high-pressure compression fitting and can be installed merely by tightening a gland nut in the same manner as when making a superpressure connection. Choice of iron-Constantan or Chromel-Alumel; welded at tip; plug and sheath made of 347 stainless steel. —*American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.*

For more information circle **324** on inquiry card.

UNIVERSAL THERMOCOUPLES

New "Green Tip Couples" offer unique combination of fast response, Mg-O-insulated TC welded integrally

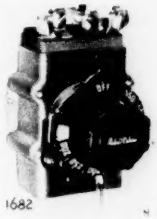


1801

with sheath, electrically-insulated from thermowell or overtube; operating temperature range —320 F to 1900 F; pressure range vacuum to 2000 psi; resistance to erosion, corrosion and nuclear radiation.—*Aero Research Instrument Co., Inc., 315 N. Aberdeen St., Chicago 7, Ill.*

For more information circle **325** on inquiry card.

THREE-PHASE THERMOSTAT



1682

New Model D33 electric thermostat, available in nine temperature ranges up to 700 F, controls three heating phases: one is ON continuously when dial is moved from OFF position; two other phases are controlled thermostatically and automatically cycle with changes in temperature.—*Robertshaw-Fulton Controls Co., Youngwood, Penna.*

For more information circle **326** on inquiry card.

SUPERHEAT CHECKING KIT

New thermometer kit designed specifically for checking superheat consists of two identical 2" dial Serviceman thermometers, each graduated —40 F to 65 F and equipped with a 12" double-armor capillary tubing, small (¼" dia) sensitive

DRIFT FREE TO 1000°F

A gage combining a miniature thermocouple and new strain sensitive element in one unique package.

• Long term stability for static strain measurements • Fast installation time using P•B•X ceramic cement • Available in sizes ¼", ⅛", and smaller.

For further information write to:

HIGH TEMPERATURE INSTRUMENTS CORPORATION
#1 Highland Avenue, Bala-Cynwyd, Pa.

For more information circle **93** on inquiry card.

HOW
BORG EQUIPMENT DIVISION
CAN HELP YOU

Our business is helping to solve design and production problems in the use of components for the highly specialized electronics industry. Borg's background provides the experience necessary to design and produce various types of components for you . . .

MICROPOT* POTENTIOMETERS

Borg Micropots offer a wide range of high-precision, single-turn, multiturn and trimming potentiometers.

**Registered trademark of The George W. Borg Corporation.*

MICRODIALS

Direct Reading Microdials and Concentric Scale Microdials.

INSTRUMENT MOTORS

Rugged, dependable Borg-Motors are designed for quality instrument applications.

AIRCRAFT INSTRUMENTS

Instruments for commercial and military aircraft.

FREQUENCY STANDARDS

To meet your requirements in Frequency Standards for military or industrial applications.

TEST EQUIPMENT FOR AUTOMATION

Invaluable experience with automatic testing equipment is yours when you call on Borg.

Save time and money when faced with design or production problems of electronic components. Call on Borg. Let us send you the name of your nearest Borg "Tech-Rep" and a copy of catalog BED-A90 today.

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The George W. Borg Corporation is comprised of three divisions . . . the Borg Equipment Division at Janesville, Wisconsin, the Borg Fabrics Division at Delavan, Wisconsin which manufactures the fashionable "Borgana" fabric for coats and jackets and the Borg Products Division at Jefferson, Wisconsin, leading manufacturer of automotive clocks.

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MOTORS
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BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information circle **94** on inquiry card.

NEW INSTRUMENTS

bulb, and a handy ring at top of thermometer case. Two non-absorbent oil-resistant foam-rubber wrappers are provided for attaching bulbs to points of measurement and also for insulating bulbs from ambient temperature. Kit includes instruction booklet and clear plastic box.—*Marsh Instrument Co., Skokie, Ill.*

For more information circle **327** on inquiry card.

SURFACE TEMPERATURE THERMOMETRIC PICKUPS

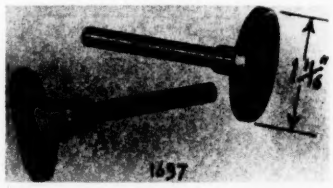
New Cement-On (Type 1375) and Weld-On (Type 1376) platinum-resistance units can be installed on any

surface; are available in various ranges between −400 F and 1550 F; outputs up to 5 volts without amplification, usable for standard FM/FM telemetering; stand 100-G acceleration on 3 axes. Calibration certificate supplied with each unit.—*Trans-Sonics, Inc., Burlington, Mass.*

For more information circle **328** on inquiry card.

DIAL THERMOMETER

New Model G, for installation on any type of equipment where mounting space is limited, is of direct-drive



bimetal coil type (no gears and linkage); moisture-sealed, overheat-protected, pressure-proof and individually calibrated. Eleven ranges; stems from 2½" to 72".—*W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.*

For more information circle **329** on inquiry card.

CLASSROOM T & V CONTROL

New automatic control package, specifically designed for controlling combination hot and chilled water unit ventilators, combines a dual-element unit-mounted room and discharge controller with an oil-submerged spring-return motor operator and a changeover thermostat.—*Barber-Colman Co., Rockford, Ill.*

For more information circle **330** on inquiry card.

flow-rate, volume, weight, level

REMOTE-READING METER

New industrial-chemical liquid meter comprises a vortex-type meter with an electric counting device, and

a remote counter. Many counters can mount on one panel. Key resets counter and prevents tampering.—*Hersey Co., Watertown, Wis.*

For more information circle **331** on inquiry card.

PITOT TUBE

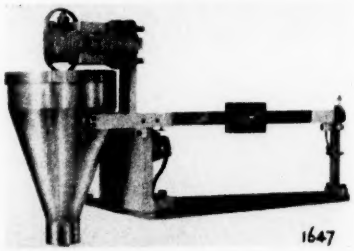
New Pitot tube, made of stainless steel, bronze, brass or Monel, requires

an exceptionally small opening for insertion into pipe or duct; features: (1) safety lock which permits new tube to be secured in any position (even when running a traverse) and which automatically positions tube so that impact opening always faces exactly upstream for maximum accuracy; (2) differential pressure about 25% to 50% greater than with conventional Pitot tubes.—*C-Mar Corp., Manasquan, N. J.*

For more information circle **332** on inquiry card.

LIQUID WEIGHER-FEEDER

New Automatic Liquid Weighing Unit has range of 1 oz to 10 lb with output up to 10 weighings per minute;



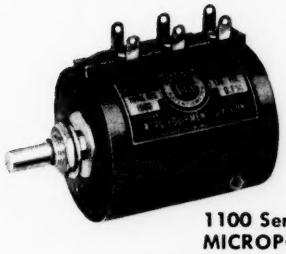
utilizes a specially-designed pneumatically-actuated bulk and trim flow valve connected to users' supply tank by flexible tubing. After poise is set for desired weighment, control switch is turned on, starting liquid flow into

Why Gamble?

THERE'S A BORG MICROPOT® TO MEET YOUR EXACT SPECIFICATIONS!

BORG MICROPOTS... the Ultimate in Multi-Turn Precision Potentiometers

Borg offers a complete line of high-precision, linear potentiometers called MICROPOTS. Precision is Borg's business . . . that's why MICROPOTS offer so many exclusive advantages. Superior design and production methods make Borg MICROPOTS available in any quantity. Write today for the name of your nearest Borg Jobber or "Tech-Rep."



1100 Series MICROPOTS

A precision MICROPOT that offers your products a price advantage in today's competitive markets. Lug or lead type terminals. Accurate . . . dependable . . . long lived.

900 Series MICROPOTS

Standard ten-turn and three-turn models to fit most special design needs. Extremely accurate and dependable under adverse environmental conditions including severe vibration and shock.

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A quality MICROPOT. Designed for both military and commercial applications. Proven in many different mobile and stationary types of electronic circuitry.

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Small in size, lightweight, rugged and dependable. Three types of terminals . . . printed circuit, solder lugs or insulated wire leads.

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For more information circle **95** on inquiry card.

FIRST AND ONLY...

MINIATURE TWO PEN 5" RECORDING POTENTIOMETER

Transistor Amplifiers

exclusive from...

westronics® INCORPORATED

$1195.00*

THE ULTIMATE IN AN ACCURATE, READABLE, MINIATURE RECORDING POTENTIOMETER, WITH THESE ADVANCED FEATURES

- 5-inch strip chart record.
- Two pens, each traveling the full 5 inches.
- 1-second maximum balancing time.
- Table top or panel mounting.
- Panel space 9⅝" W x 8½" H
- Margin marker pens.
- Paper supply indicator front of recorder.
- Ball bearings in pen drive system.
- New concept in front set limit switches.
- 0.5% accuracy on both pens.
- Completely transistorized amplifiers, no vacuum tubes.
- MV or TC Calibration
- Minimum Span: 1 MV
- Standardization: Mercury cell.
- Simple sub-assembly type construction for easy maintenance. (Entire recorder rolls forward out of case.)

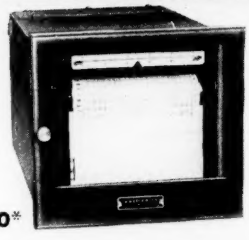
PLUS THESE OPTIONAL FEATURES:

- One front set SPDT switch and 3 SPDT back set switches each independently adjustable over the entire range on each pen.
- Transmitting slidewires.
- Selsyn motor chart drive.
- 3 speed quick change chart drive.
- Left and/or right margin marking pens.

WESTRONICS RECORDING POTENTIOMETERS FOR EVERY NEED

One Pen Miniature 5" Recording Potentiometer

- 5" strip chart record.
- Continuous Automatic Standardization with electron tube amplifiers.
- Requires only 9⅝" by 8½" panel space.
- Accuracy better than 0.5%.
- One second full scale pen travel.
- Weighs less than 25 pounds.



$490.00*

Two Pen 11" Recording Potentiometer

- 11" strip chart recorder (12" overall width).
- Completely transistorized amplifiers.
- Reduced maintenance.
- Small size.
- Immediate recording . . . no warm-up time.
- Optional synchronous motor or Selsyn motor chart drive.

$1495.00*

*BASE PRICE

For more information circle 96 on inquiry card.

NEW INSTRUMENTS

tank, first at a high rate, then slowing in order to obtain extremely accurate final weight. Impulse from external source opens discharge valve and permits liquid to flow from weigh tank. Upon completion of discharge, cycle can be repeated automatically if desired.—*Glengarry Processes Inc., Bay Shore, N. Y.*

For more information circle **333** on inquiry card.

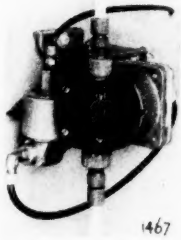
ANEMOMETER CELL

1436

New Model 9580 is of thermal conductivity bridge type, for measuring (a) extremely low gas flows (to 1 cfh) at constant pressure, or (b) pressure drops across an orifice as a function of flow-rate where a portion of stream is by-passed through cell. Sample can flow in either direction. Current required is 0.2 amp at 1.5 vdc.—*Gow-Mac Instrument Co., 100 Kings Road, Madison, N. J.*

For more information circle **334** on inquiry card.

CHEMICAL FEEDER



1467

New Model 19130 Proportioneer, for safe handling of concentrated chemicals feeding directly from shipping containers, has been redesigned to make it even more compact and easier to install. It is wall-mounted; its initial cost is ⅓ that of most similar units; it can be installed in minutes by unskilled labor. Pumping rates adjustable from 0.8 to 8 gallons per 24-hour period.—*Proportioneers, Inc., 345 Harris Ave., Providence, R. I.*

For more information circle **335** on inquiry card.

LIQUID LEVEL CONTROLLER

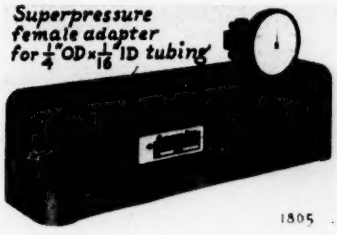
New Bubbler System keeps liquid levels from varying more than ¼"; utilizes change in back pressure of air being bubbled through liquid as level changes. This back-pressure variation is used to position a Flowrite diaphragm control valve on liquid supply line. If necessary, bubbler placed below liquid surface can be coated (with Teflon, for example) to prevent caking. After system is installed, liquid level can be adjusted over a range of 1½"; adjustment is made on control point of static regulator.—*Powers Regulator Co., 3434 Oakton St., Skokie, Ill.*

For more information circle **336** on inquiry card.

pressure and vacuum

EXTREME PRESSURE GAGE

New extreme pressure gage measures pressures up to 100,000 psi. Instead of curved thin-walled pressure



tubes, a heavy-walled chrome-nickel molybdenum eccentric tube, virtually straight at atmospheric pressure and tending to curve slightly as pressure is applied. This tube is surrounded by a heavy-walled cast iron case with sheet metal safety back. Indicator is not part of pressure system, whence further safety.—*American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.*

For more information circle **337** on inquiry card.

SENSITIVE L-P SWITCH

New economically-priced ultrasensitive low-pressure or low d p switch features an independently adjustable automatic reset; can be mounted in any position and is unaffected by vibrations; fits into a 3½" x 7½" area. Since there is no flow through sensing element, connecting tubing can be as small as ⅛" ID.—*Bacharach Industrial Instrument Co., 200 N. Braddock Ave., Pittsburgh 8, Pa.*

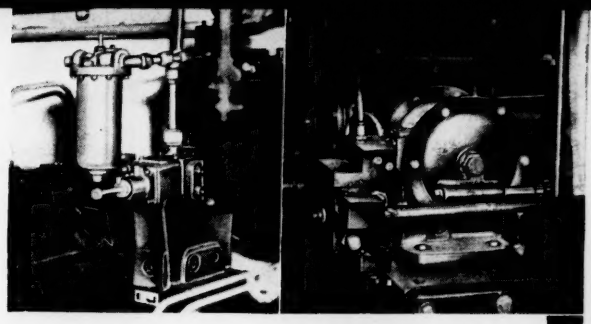
For more information circle **338** on inquiry card.

motion, acceleration

H-T AND EXPLOSION-PROOF DISPLACEMENT PICKUP

New Atcotran Differential Transformer enclosed in a Heliarc-welded stainless steel shell is explosion-proof and operates in temperatures up to 500° F. Coil, wound with glass-insulated wire, is vacuum-impregnated with a silicone varnish; stainless steel stuffing box is welded to housing.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

For more information circle **339** on inquiry card.



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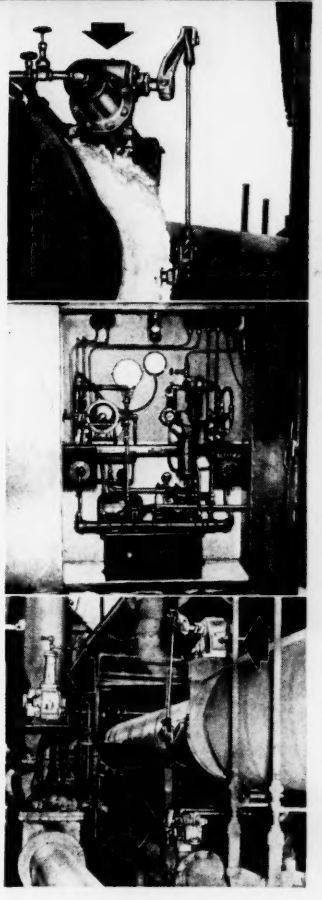
Key Component for those TOUGH CONTROL JOBS

THE ASKANIA JET PIPE RELAY



THE ASKANIA JET PIPE RELAY, nucleus of Askania Controllers for pressure, flow, proportioning, combustion and position, is designed for the TOUGH control jobs. You can depend upon it for the operation of LARGE, HEAVY valves, dampers, engine throttles and other final control elements or those having high thrust requirements.

The Askania Jet Pipe Relay provides double acting positive correcting power which opens and closes the valve without the need of a spring return.

Shown on this page are typical examples of Askania's ruggedly constructed Jet Pipe Control systems used for flow, pressure, proportioning and combustion control applications. Askania Jet Pipe Controllers:

- operate equally well indoors and outdoors—won't freeze
- operate even under the most adverse ambient conditions
- are easily installed
- require minimum maintenance
- give instantaneous response to minute changes in the measured variable

Send for General Catalog which describes and illustrates how Askania Jet Pipe Regulators can be applied to various process applications...shows you the solution to your own tough problems. Write Askania Regulator Company, 268 E. Ontario St., Chicago, Illinois

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For more information circle **98** on inquiry card.

NEW INSTRUMENTS

ANGULAR POSITION PICKUP

New single-coil variable-reluctance angular transducer for FM/FM telemetering applications utilizes a new principle: rotation of a magnetic rotor varies amount of ferromagnetic material in a fixed air gap and, owing to rotor shape, a reluctance change varies oscillator frequency linearly. Among features: infinite resolution for small angular ranges without using gears or screw systems to obtain adequate output sensitivity; no need of mechanical stops to prevent damage since continuous shaft rotation is possible without damage or change in calibration.—*Ultradyne, Inc., P. O. Box 3308, Albuquerque, N. M.*

For more information circle **340** on inquiry card.

TORQUE GENERATOR LINEAR ACCELERATION PICKUPS

New high-precision acceleration pickups utilize torque generator restraint in place of usual torsion bar;

feature operation in a closed-loop servo system, whence highest-order precision. Unbalance weight is housed in a sealed cylinder floated in exact equilibrium in a high-density viscous fluid, removing load from jeweled bearings while providing viscous damping.—*Reeves Instrument Corp., 207 E. 91st St., New York 28, N. Y.*

For more information circle **341** on inquiry card.

inspection and dimensional gaging

BORE TELESCOPE

New Hole Inspection Telescope has a lens bulb that shoots a beam of light into a hole too small for a light probe. A $\frac{1}{8}$" dia mirror is available for side viewing holes from 0.125" up; also side viewing adapters with diameters of 0.123" to 0.500". —*Dept. 124, Eder Instrument Co., 2293 Clybourn Ave., Chicago, Ill.*

For more information circle **342** on inquiry card.

BORE TELESCOPES

New Model TG-2 Borescopes, for internal inspection of small-diameter cavities, are available with minimum bore diameters of 0.16", 0.20" and 0.28", and lengths from 5" to 30".—*Koilmorgen Optical Corp., 347 King St., Northampton, Mass.*

For more information circle **344** on inquiry card.

OPTICAL COMPARATOR

New "Big Twin Eighteen" offers both a large (18" dia) screen and duplex operation: used either as a vertical (floor type) model or in horizontal (bench type) position. New optical system offers brightest possible images, unusual crispness at all seven magnifications from 10× to 100×, and geometrical correctness.—*Portman Instrument Co., Town Dock Road, New Rochelle, N. Y.*

For more information circle **343** on inquiry card.

MICROSCOPE-PROJECTOR-COMPARATOR-CAMERA

New "Projectina" multi-purpose Swiss-perfected precision instrument features rapid interchange of optics,

of photographic equipment, of stages, etc.—*Alfred Hofmann & Co., 629-635 59th St., West New York, N. J.*

For more information circle **345** on inquiry card.

"We learned to use the Bendix G-15 computer in just four hours."

Anyone who can learn to operate a desk calculator can now use an electronic computer. New techniques developed for the Bendix G-15 Digital Computer make it so easy to use that the fundamentals can be mastered in thirty minutes...a working knowledge of programming in four hours or less. The G-15 can be used by the men who know their own problems best, right in their offices and laboratories, and often at 1/10th the cost of "computing center" installations.

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For more information circle **99** on inquiry card.

timers and counters

REPEAT-CYCLE TIMER

1652

New Series PC Percentage Recycling Timer, available in 12 time cycles from 15 sec to 24 hr, has dial calibrated in percent; closes an electric circuit for any desired part of a fixed time cycle. On-time is adjustable from 3% to 97%. Special dials calibrated in degrees, gallons, etc., are available. —*Industrial Timer Corp.*, 1407 *McCarter Highway, Newark* 4, *N. J.*

For more information circle **346** on inquiry card.

THERMAL DELAY RELAY

New miniature Thermaline features high shock and vibration characteristics (OK for aircraft); silver con-

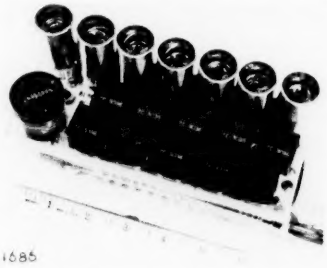
1660

tacts can carry 3-amp 115-vac noninductive for over 250,000 operations. Operating voltages from 6 to 155; timing ranges n-o or n-c ¼ sec to 3 min.—*Line Electric Co.*, 271 *So. 6th St., Newark* 3, *N. J.*

For more information circle **347** on inquiry card.

BINARY COUNTER

New Model 301-D uses field-replaceable magnetic-core transformers which make it impervious to long-



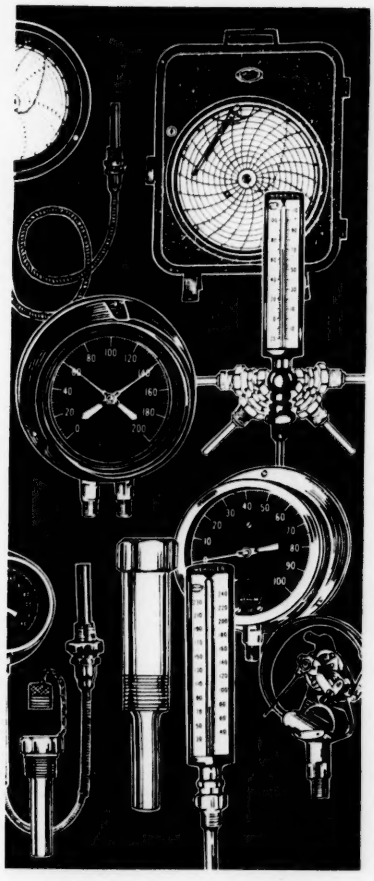
1685

term tube-characteristic changes and insensitive to voltage and temperature variations.—*Telechrome Mfg. Corp.*, 28 *Ranick Drive, Amityville, N. Y.*

For more information circle **348** on inquiry card.

COUNTER READOUT

New Model 401A In-line Readout assures accuracy in presentation: each numeral is formed by many



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For more information circle **100** on inquiry card.

small high-intensity neon bulbs; failure of two or three bulbs, would not affect accurate recognition—but neon

bulbs rarely burn out. Two or more in-line readouts can be activated by one counter.—*Computer Measurements Corp., 5528 Vineland Ave., North Hollywood, Calif.*

For more information circle **349** on inquiry card.

HYDRAULIC-ACTION COUNTER

New 5-digit automatic counting device specifically designed for any operation controlled by hydraulic action requires only 5 minutes to install; sells for less than usual installation costs but is said to outwear and outperform mechanical counters: no damaging overtravel and no error-producing undertravel. It registers up to 300 counts per minute, is available in either knob or "tamperproof" key reset, with hydraulic units 50 to 8000 psi. Snap-on attachments are available for individual operators. If desired, a machine can be set so that absence of a counter will make it inoperative.—*Pneumaticount, 3400 E. 54th Ave., Portland, Ore.*

For more information circle **350** on inquiry card.

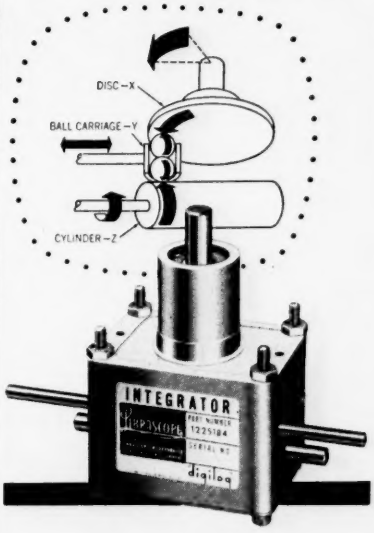
PREDETERMINING COUNTER

New Tally 1000 Pre-determined Counter, said to be "the lowest-cost unit of its type on the market today,"

can be actuated by any type of sp-st switching device, can be used to control motors, etc. Counting rates up to 450 per minute.—*Hobson Miller Machinery Corp., 280 Lafayette St., New York 12, N. Y.*

For more information circle **351** on inquiry card.

Primary parts of the Librascope Ball and Disc Integrator are a rotating input disc (X), two counter-rotating steel balls enclosed in a carriage (Y), and an output cylinder (Z). The cylinder speed is proportional to the product of the disc speed and the ball carriage position. The disc speed and ball carriage position can be continuously variable.



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For more information circle **102** on inquiry card.

nucleonics

SCINTILLATION DETECTOR

New P-20C modification of maker's scintillation detector extends its usefulness over a broader range; incorporates a by-pass switch on its back plate which permits pulses of photomultiplier tube to by-pass built-in stable pulse amplifier and to be fed directly to linear amplifiers used for spectrometry.—*Tracerlab, Inc., 1601 Trapelo Road, Waltham 54, Mass.*

For more information circle **352** on inquiry card.

SCANNING-COUNT COMPUTER

New Model 540, for automatic histogram plotting of spectral information, represents a new concept in nuclear radiation instrumentation, can be used for studies of spectral effects (absorption or scattering), and spectral examination for isotopic identification and purity; can also perform continuous studies of radiation output of high-voltage machines, as well as scintillation and proportional spectrometry. Operating on principle of count integration (theoretically similar to scaler storage), it accumulates pulse information for predetermined time intervals, displays total count, then automatically steps to the next of its 100 information channels.—*Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.*

For more information circle **353** on inquiry card.

NEUTRON SURVEY METER

New EKCO Model N-578 Slow Neutron Survey Meter meets rigid construction and performance requirements of British Atomic Energy Research Establishment, features rapid response, zero stability linear scale, 80:1 discrimination against gamma dose rate.—*American Tradair Corp., 34-01 30th St., Long Island City 6, N. Y.*

For more information circle **354** on inquiry card.

RADIATION SURVEY METER

New complete line of hand-portable radiation-monitoring instrument, designed for commercial use but meet-

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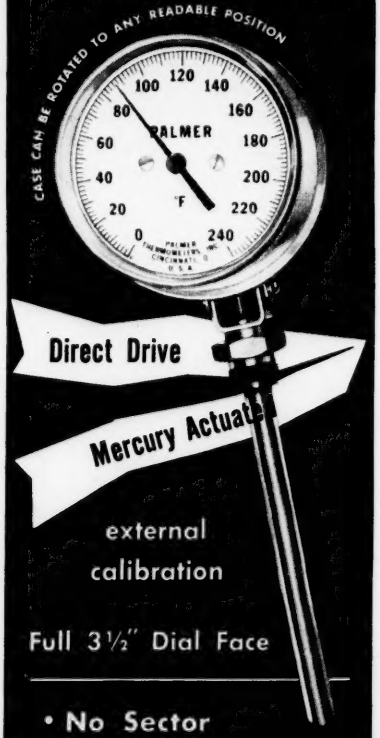

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Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

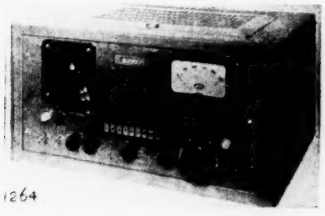
For more information circle **103** on inquiry card.

ing strict government specs, includes 4½-lb Model UAC 700 all-transistorized survey meter that operates from standard flashlight cells for more than 250 hours of continuous use.—*Universal Transistor Products Corp., 143 E. 49th St., New York 17, N. Y.*

For more information circle **355** on inquiry card.

RADIOACTIVITY COUNTER

New Model PC-1A Proportional Counting System, said to be "the most precise radioactivity-counting instru-



1264

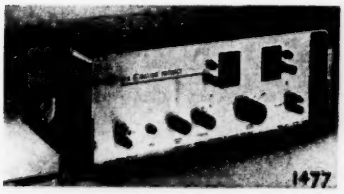
ment ever developed," counts alpha in presence of beta, and total of alpha and beta-gamma; can count every alpha and every beta emitted from sample regardless of their energies.—*Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.*

For more information circle **356** on inquiry card.

lab equipment

CHROMATOGRAPH READOUT

New Chromatograph Readout provides instantaneous integrated digital readout of signal peaks produced by



1477

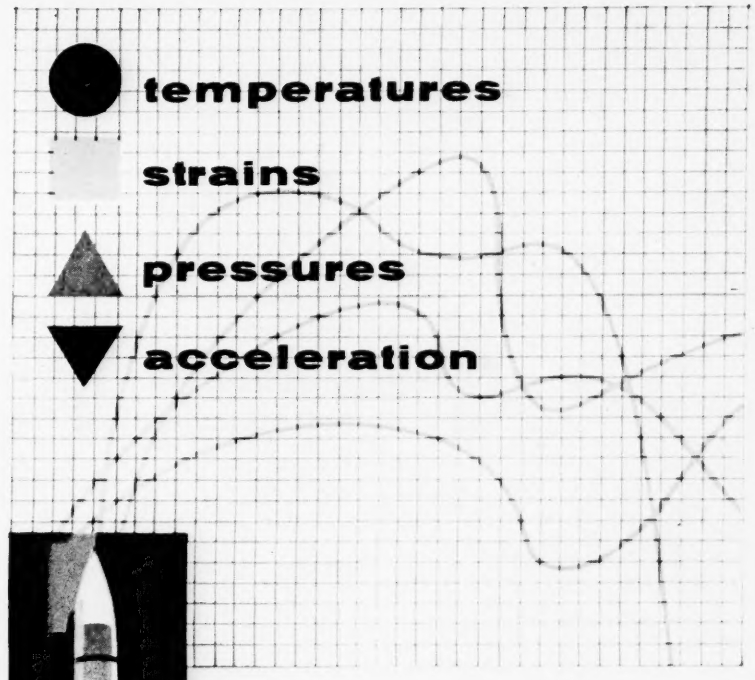
currently-used chromatographs; eliminates laborious calculations.—*Southwestern Industrial Electronics Co., 2831 Post Oak Road, Houston 19, Texas.*

For more information circle **357** on inquiry card.

PHOTOELECTRIC COLORIMETER

New WEKA does not require a standard solution; can be used in full daylight; yields readings on a 1000-

1641



201 PLOTTER—Plots visibly at speeds up to 8 points per second with 4 symbols, or up to 20 per second with random symbols. Plots immediately the results of computers . . . continuous paper feed, automatic grid printing. Input from digital computers, card readers, or paper tape. Or you may have need for our new **Visual Recorder** to plot twelve selected flight-test variables. These are but two Tally developments available for fast, precise data handling which have accrued in several years of special assignments for the nation's leading aircraft manufacturers and government agencies. Write for details about these specific products, or Tally's unique qualifications for developing special digital data systems and related devices. *(Facility brochure available upon request.)*

Model 201 Digital Plotter

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REGISTER CORPORATION Department 100, 5300 14th N.W., Seattle

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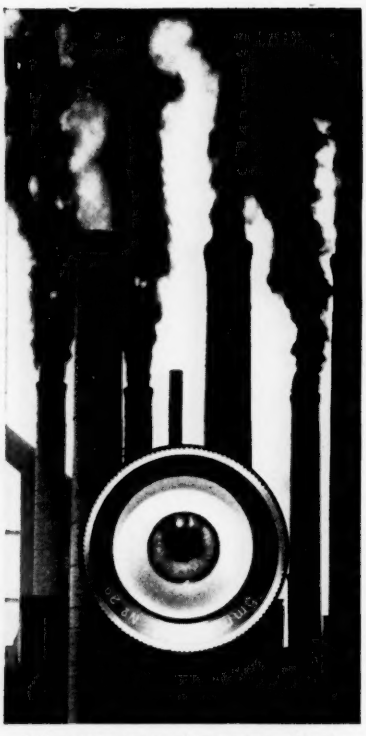

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For more information circle **105** on inquiry card.

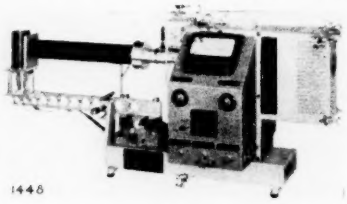
NEW INSTRUMENTS

division drum, whence much better accuracy (0.1%-0.2%) than on the short scale of a galvanometer. Use of two photocells in a balanced circuit makes measurements independent of photocell sensitivity characteristics and of fluctuations of light intensity. Available: several kinds of lamps for polychromatic or monochromatic light and for fluorescence measurements; wide assortment of cuvettes; special flame photometric attachment for colorimetric as well as photometric measurements.—*EPIC, Inc., 154 Nassau St., New York 38, N. Y.*

For more information circle **358** on inquiry card.

TRANSMISSION METER

New Model II Scattermaster, for transmission measurements of films and sheets which are important in

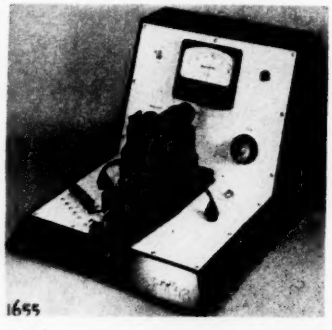


determining surface imperfections, also permits measurements on sheets and liquids which are important with respect to determining sizes of macro molecules. Minutely controlled observations can be taken over angles from 0 to nearly 90° with respect to incident angle. (Special units for measurements at greater than 90°).—*Manufacturers Engineering & Equipment Corp., Hatboro, Pa.*

For more information circle **359** on inquiry card.

FLUOROMETER

New Galvanek-Morrison Fluorometer determines beryllium and uranium in solutions, (particularly biological products); has been tested and approved by a lab operating under AEC; is said to be "the most sensitive commercially available apparatus yet developed for determinations of beryllium in solutions."—*Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.*



For more information circle **360** on inquiry card.

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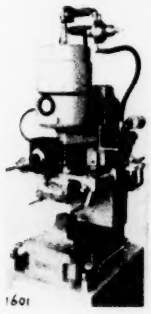
shop equipment

HOT STAMPING MACHINE



New 1958 model of No. 250 has many advances over former model, among them: simpler and more powerful air pressure system; greater heat capacity in die head; new die and type holder is an adjustable and removable slide.—*The Acromark Co., 378 Morrell St., Elizabeth, N. J.*

For more information circle **361** on inquiry card.

SPRING COILER

New model of maker's variable-speed spring coiler features ¾ hp motor, speed selector, and clutch

lever for setting up job before moving into desired speed.—*Perkins Machine and Gear Co., West Springfield, Mass.*

For more information circle **362** on inquiry card.

LENS CURVE GENERATOR

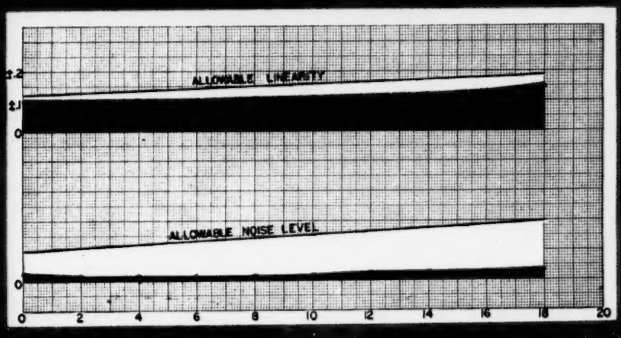
New vertical Model WB25 Lens Curve Generator (made in Germany) evolved from field experience accumulated with horizontal WB15, offers mass-producing optical shop lower first costs, increased operating efficiencies, closer positioning of work for more convenient multi-spindle operation; can be ordered in compact double or triple units. Principal operational feature is high-rate "milling" stock removal with remarkably fine finishes.—*Alfa American Corp., 303 W. 42nd St., New York 36, N. Y.*

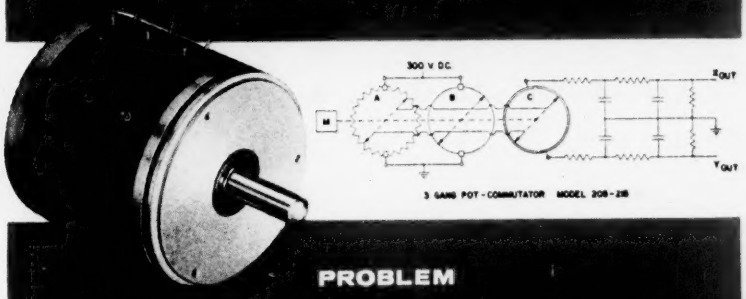
For more information circle **363** on inquiry card.

ANGULAR DIVIDER

New Model D-3 positions shafts of synchros, pots, and other rotating components to an accuracy of 20 sec of arc; obviates flexible couplings by

18,000,000





PROBLEM

SOLUTION

GIC

COMPUTER INSTRUMENTS CORPORATION

For more information circle **107** on inquiry card.

Post Decitron
electronic products

Model SD-1T

This *new* Post electronic counter outmodes all mechanical counters. Capable of operating at speeds up to 100 units per second, a single "count" is indicated on the six digit totalizer as each *tenth* item breaks the light beam. For counting dozens or gross a 12 place counting tube can be substituted. May be operated from microswitch, photohead or Post magnetic switch.

Standard SD-1T **$140.00**

Model SD-1

Same as above, without totalizer. Boosts service life of mechanical registers 15 times by counting in units of 10. Can be placed several hundred feet from switch contacts.

SD-1 ..... **$98.00**
With Remote Totalizer **$125.00**

Model MH-2

Magnetic Switch . . . high speed — ideally suited to sensing applications — will actuate electronic counters, mechanical counters, controls, solenoids, relays and many other circuits. Capable of speeds up to 100 cycles per second. Long service life.

Feature . . . sharp, clean make or break — no lag, no bounce.

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☐ Send literature on Model _____
☐ Please send name of nearest representative

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For more information circle **108** on inquiry card.

NEW INSTRUMENTS

a new technique of using synchro shaft to locate center or rotation of synchro housing; can be handled by

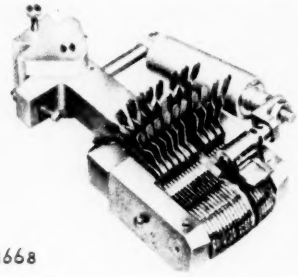
1482

unskilled operators. Weight 30 lb; diameter 12".—*Theta Instrument Corp., 48 Pine St., E. Paterson, N. J.*

For more information circle **364** on inquiry card.

AUTOMATIC NUMBERING HEAD

New Model 484 is said to combine 5 unique features never before incorporated in a numbering head. In-



1668

stead of usual cam or lever arrangement, indexing is accomplished by an air cylinder.—*Noble & Westbrook Mfg. Co., East Hartford, Conn.*

For more information circle **365** on inquiry card.

SMALL PARTS STORAGE

New Model R-156 Load Lugger racks save floor space, enable parts to be stored loose yet accessibly; come

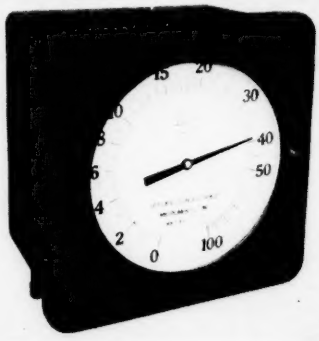
1664

in various sizes; cost about half the price of comparable small-parts storage equipment.—*McClintock Mfg. Co., Industrial Sales Dept., 802 W. Whittier Blvd., Whittier, Calif.*

For more information circle **366** on inquiry card.

Self-Balancing
INDICATOR-CONTROLLER
Type RI

For Measurement of Electrolytic Conductivity



A COMPACT, self-balancing instrument, the RI Indicator-Controller is used for the measurement and control of solution concentrations in industrial processes not requiring recording. The exceptional flexibility of the instrument permits its use for any measurement of electrolytic conductivity from the very highest resistance of pure water and condensed steam to the low resistance of concentrated solutions of acids, alkalis and salts.

FEATURES:

- True AC Wheatstone Bridge
- Large easily read scales
- Plug-ins for automatic or manual temperature compensation
- Self-balancing: responds immediately to any change in solution conductivity
- Available as a multi-range instrument for laboratory use, replacing manual balance bridges
- Many types of control accessories available.

Send today for catalog covering complete line of conductivity cells and instruments.

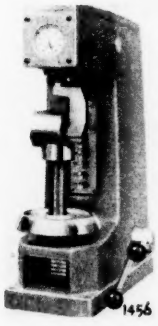
Industrial Instruments

89 Commerce Road, Cedar Grove, Essex County, New Jersey

For more information circle **109** on inquiry card.

mechanical testing

HARDNESS TESTER

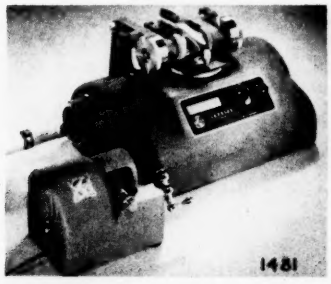


New Frank Universal Hardness Tester (West German made) features arrangement whereby 8 different loads are selectively available by push-button control for choice of: Rockwell C by "Brale" penetrator, Rockwell B by $\frac{1}{16}$" steel ball, Brinell by 2.5, 5 and 10 mm steel balls, and Vickers by 136° diamond penetrator.—*Opto-Metric Tools, Inc., 137 Varick St., New York 13, N. Y.*

For more information circle **367** on inquiry card.

ABRASION TESTER

New 1958 Model Abrasion Testing Set comprises new improved Model 174 Abraser incorporating a built-in

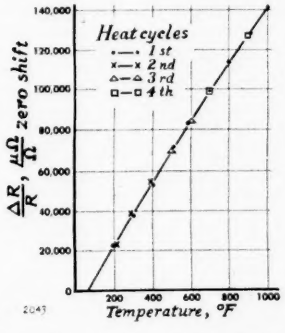


motor with a worm reduction drive, automatic stop electric counter, and new selector circuit; new Model 200 Wheel Refacer; plus accessories and supplies.—*Taber Instrument Corp., Section 75, N. Tonawanda, N. Y.*

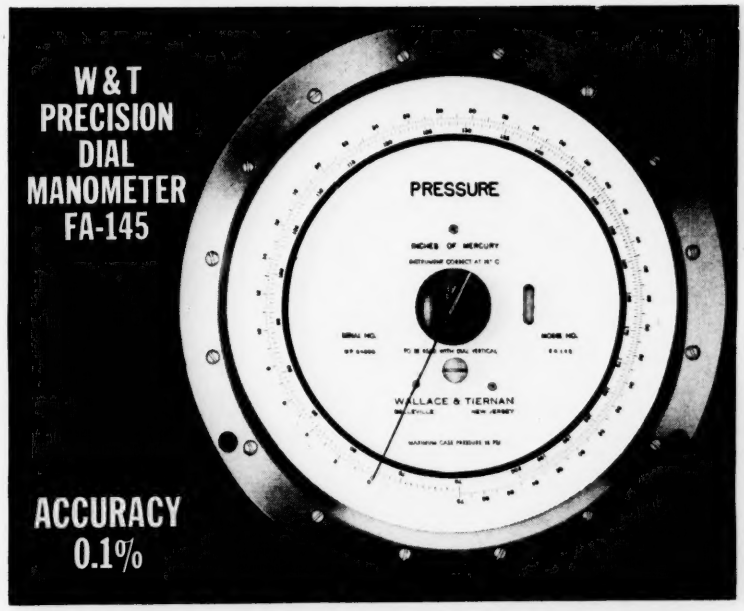
For more information circle **368** on inquiry card.

DRIFT-FREE STRAIN GAGES

Two new types of variable-resistance strain gages are drift-free when used within their specified tempera-



ture ranges: (1) HT-600 Static is drift-free up to 600°F; (2) HT-1200 has been tested to 1000°F without



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Accuracy:	1/1000 of full scale
Sensitivity:	1/10,000 in *all* ranges
Ranges:	0 to 120 inches of water (min.) 0 to 300 inches of mercury (max.) Other intermediate ranges available
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Dial Size:	8½ inches

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For more information circle **110** on inquiry card.

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Remote Reading Liquid Level Gage

Flashing Red Scale Warns of Danger

Jerguson Truscales are now available with a unique new safety feature. Illuminated scale starts flashing red if boiler water level gets too high or too low. This positive warning flashes continuously until the dangerous condition is corrected.

Truscales offer the greatest possible protection for expensive equipment. They give instant remote reading of liquid level of boilers, tanks, etc., with the amazing accuracy of ½ of 1% of scale reading. Convex face, with scale markings directly on it, gives 180° visibility. It's easy to take readings from any point from which the face can be seen.

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For more information circle **111** on inquiry card.

NEW INSTRUMENTS

apparent drift. Each is a combination thermocouple and strain gage, with TC measuring junction in plane of grid for exact compensation. Standard size ⅛" x ¼"; other sizes such as ¼" x ½".—*High Temperature Instruments Corp., Bala-Cynwyd, Penna.*

For more information circle **369** on inquiry card.

ENGINE ANALYZER

New Type 2662 Industrial Engin Scope permits, for the first time viewing secondary signal information—the unknown in system analysis on low-speed industrial engines. It is the only oscilloscope engine analyzer for spark-ignited industrial equipment to feature a multi-line presentation, cylinder-by-cylinder. Each cylinder operation, from firing of spark to points open, is shown on screen, one line below the other in engine's exact firing order. Maker's exclusive Signal-Clips obviate need of disturbing system or piercing the wires.—*Allen B. Du Mont Labs., Inc., 750 Bloomfield Ave., Clifton, N. J.*

For more information circle **370** on inquiry card.

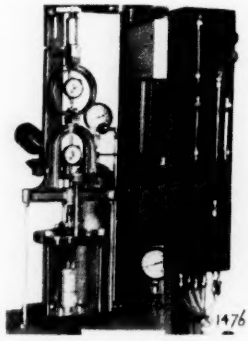
MOBILE WELD ANALYZER

New Mobile Analyzer Recorder simultaneously depicts and records current and force applied to electrodes of stored resistance welding machines; records strains as low as 10 microinches per inch and currents as low as 1 ma. Weight 100 lb; height 31"; rubber-tired non-static self-locking casters. Record charts are page-numbered and are accordion-folded for easy access.—*Edin Co., 207 Main St., Worcester 8, Mass.*

For more information circle **371** on inquiry card.

SOIL TESTER

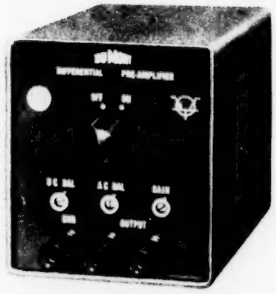
New Triaxial Test Apparatus enables laboratory re-enactments of the three dimensional stresses on a given



soil, up to failure point; has transparent test cell and specimen cap which enable operator to observe specimen through every stage.—*Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.*

For more information circle **372** on inquiry card.

Common Mode Rejection to 1,000,000:1



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For more information circle **112** on inquiry card.

STRAIN GAGE TRIMMER

New ac-powered device speeds up gage trimming by as much as ten times and allows better seating of gage when applied to element. It features an illuminated plexiglass base with etched positioning lines and a gage-holding fixture. Micrometric adjustment positions two cutting knives for trimming both edges of a gage within 0.002" (or only one knife for end trimming). Width range 0.100" to 1.250".—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Waltham 54, Mass.*

For more information circle **373** on inquiry card.

HUMIDITY-TEST CABINETS

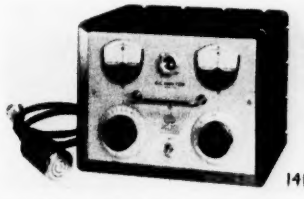
New full-range Counter-Flow Controlled Relative Humidity Cabinets are now available with dry-bulb temperatures from 32 F to 135 F and controlled RH from 20% to 98%; are constructed of all polished stainless steel, inside and out, with full inner glass door. Vapor-pressure system assures temperature uniformity and control of humidity with no wet-bulb control wick to change. Conditioning cabinet is isolated from test chamber. Built-in 2-point programming utilizes Automatic Dual Microtrol plus 24-hour timer and wet- and dry-bulb recorder; no cams to cut.—*Blue M Electric Co., Blue Island, Ill.*

For more information circle **374** on inquiry card.

electrical testing

INSULATION TESTER

New non-destructive direct-reading D-K Analyzer measures dissipation factor and dielectric constant of



1414

insulating materials; can be used to investigate effects of hardeners, fillers, and cure conditions in dielectric systems; to detect non-uniformities; to inspect incoming products; to monitor output of coating machines, etc.—*Delsen Corp., 719 W. Broadway, Glendale 4, Calif.*

For more information circle **375** on inquiry card.

VOLTAGE AND CURRENT CALIBRATOR

New Model 6020B, for precise measurement of pulse amplitudes, is designed primarily for use in magnetic core testing and grading, is applicable also to general pulse, dc, and sine-wave measurement. Two variable

One tape can't serve all recording needs in magnetic instrumentation

There are differences between pulse and carrier recording . . . therefore the tapes used in these systems must have different characteristics. Only in Soundcraft Instrumentation Tapes are these distinct and separate properties engineered into the oxide formulation. Soundcraft then adds two original processes — Uni-Level Coating and Micropolishing — to achieve the surface perfection found exclusively in the most advanced tapes of our time:

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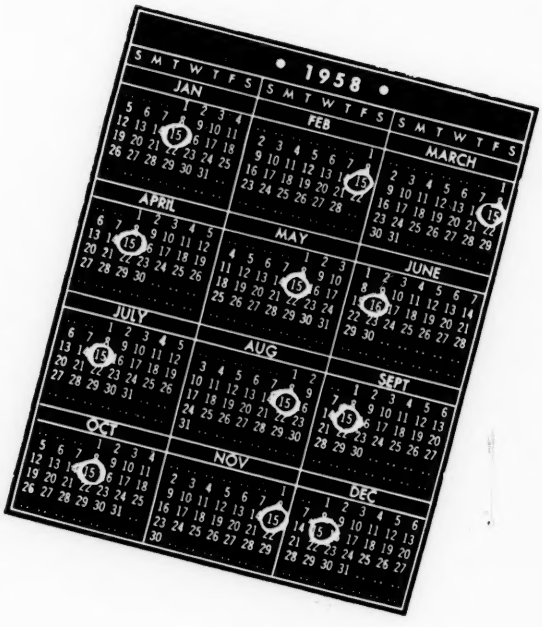

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For more information circle **376** on inquiry card.

PRECISION VARIABLE FREQUENCY OSCILLATOR

New Model 110 has a continuously-adjustable output of 100 cps to 100 kc, determined by positioning of five

digital selector switches (any frequency in this range to one part in five significant figures). A crystal-controlled reference generator assures extreme accuracy.—*Digital Instrument Labs.*, 152 *S. Atlantic Blvd., Los Angeles 22, Calif.*

For more information circle **377** on inquiry card.

FREQUENCY STANDARD

New Model FS-195 provides 10-kc, 100-kc and 1-Mc references, features high accuracy to 70 C, compactness

(483)

and versatility. Careful control of its harmonic content provides a continuous spectrum well beyond 200 Mc at usable levels so that it permits calibration of receivers in both HF and VHF bands. A 400-cps—*Transitron, Inc.*, 186 *Granite St., Manchester, N. H.*

For more information circle **378** on inquiry card.

TEST PANEL AND SUPPLY

New Electri-Panel Model 625 is a variable ac-dc power supply plus an all-purpose instrument test panel. It

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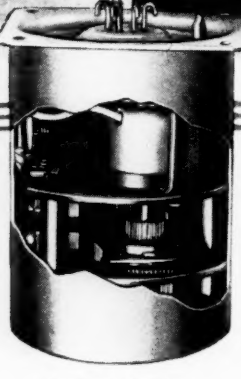


Eagle HYS Series Timer with Time Delay Feature

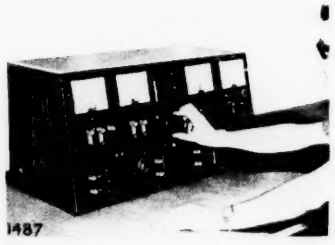
EAGLE SIGNAL engineers unique timer for Hughes airborne armament control system

A new electro-mechanical time delay device has been developed by the Eagle Signal Corporation for the Hughes Aircraft Company. Hughes uses the Eagle timer in an armament control system the company builds for the supersonic F-102A all-weather interceptor.

The Eagle timer is a hermetically sealed unit, actuated by a 28-volt d-c solenoid. The timer has been built to provide a delay in application of power to load circuit at the end of a timing interval. A rotary solenoid winds a spring on the escapement mechanism, and timing begins when the solenoid is energized. The Eagle timer operates under rigorous environmental conditions, and is built to withstand extra heavy duty applications.

Development of this special Eagle timer is just one example of the electronic and aeronautical engineering "know-how" to be found at Eagle Signal. Consult Eagle Signal on your timing and counting problems *early in your planning*. And write for Bulletin 820 for more information on the escapement timer. Eagle Signal Corporation, Dept. IA-358, Moline, Illinois.

For more information circle **117** on inquiry card.



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supplies 0-110 v ac and dc, continuously variable, at 7.5 amp maximum. —*Universal Scientific Co., Inc., Vincennes, Ind.*

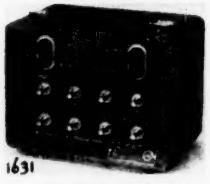
For more information circle **379** on inquiry card.

HIGH-SPEED WIRE TESTERS

New Type CVX high-voltage dc sparkers permit non-destructive fault detection at wire speeds of 4000 fpm with a zero-length electrode; represent an entirely new concept in wire sparking. High wire speeds maximize wire-making efficiency; non-destructive testing minimizes quantity of rejected wire; elimination of repetitive testing with conventional ac test sets improves quality control.—*Peschel Electronics, Inc., Towners, RFD 1, Patterson, N. Y.*

For more information circle **380** on inquiry card.

PUSHBUTTON CARRIER VOLTAGE ATTENUATORS



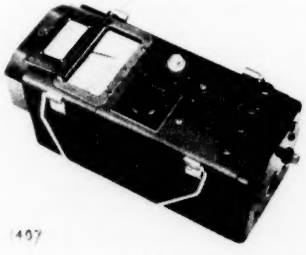
1631

New Models 40A and 41A operate in frequency range from dc to 600 kc. Pushbutton switches select values of attenuation from 0 to 82 db in 1-db steps.—*Consolidated Electrodynamics Corp., Electra Div., Pasadena, Calif.*

For more information circle **381** on inquiry card.

OHMMETER

New low-resistance self-contained direct-reading 4-range Megger for field and bench use measures accu-



497

rately down to 10 microhms; lends itself to production testing; can be flush- or bench-mounted; is available in battery or rectifier-operated models.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

For more information circle **382** on inquiry card.

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For more information circle **119** on inquiry card.

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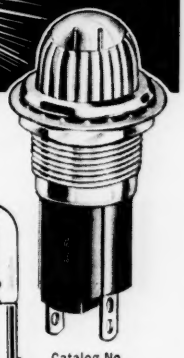
A New Advance in Pilot Light Design by DIALCO:

NE-51H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Three basic advantages are incorporated in this series of DIALCO assemblies: (1) *Built-in resistor* for direct use on 125 to 250 volt circuits... (2) *New plastic lens* designed to give attractive *"halo"* effect... (3) New High Brightness Neon Glow Lamp *NE-51H*. This lamp may be operated at about 3 times the level of current that may be applied to the standard lamp, and it will produce 8 times as much light—*with long life!* Very low power is required, less than 1 watt on 250 volt circuit. Recommended for AC service only.

In the DIALCO assembly, the built-in current limiting (ballast) resistor (18,000 ohms) is *completely insulated in moulded bakelite* and sealed in metal (U. S. Patent No. 2,421,321)... Small space required—units are available for mounting in 9/16" or 11/16" clearance holes... A wide choice of optional features includes lens styles, shapes, and colors; terminal types; metal finishes, etc.... Meet applicable *MIL Spec* and *UL* and *CSA* requirements.

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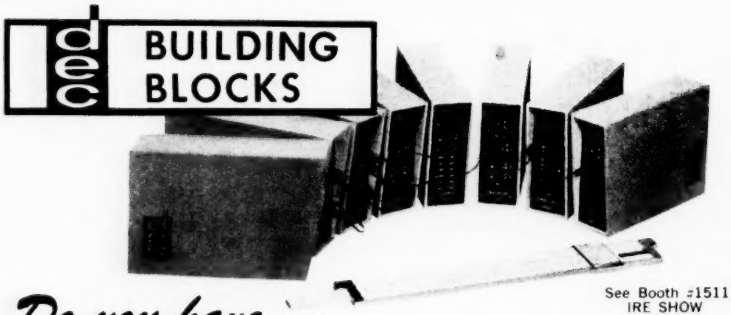

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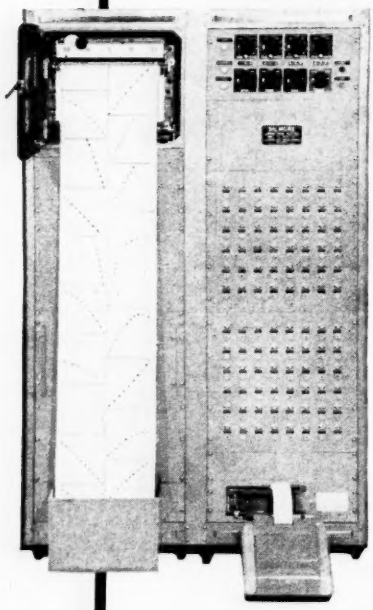
For more information circle **121** on inquiry card.

PLOT DATA "On-The-Spot"



Strain Gage, Thermocouple, or Millivolt Input

The Gilmore Model 114 Autographic Plotter is a multi-channel recording and plotting instrument for use with strain gage, thermocouple, or millivolt inputs. It automatically receives and plots each channel on an individual graph so that test personnel can quickly evaluate results, "on-the-spot", while the test is actually in progress.

Gilmore Plotters reduce reruns—help eliminate faulty test setups and overloaded test specimens. Installations save time, engineering, and technical manpower.

Model 114 Autographic Plotter is available in 24, 48, or 96 channel models. A digital converter can be driven simultaneously with the plotting to operate a tape punch, card punch, electric typewriter, or printer.

For Gilmore Bulletin 2001, Write Dept. IA-3

Instrumentation Systems for Industry and Science

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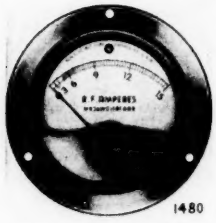
For more information circle **122** on inquiry card.

electrical and electronic instruments

R-F AMMETERS



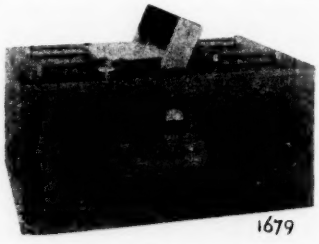
1480

New line of thermocouple type RF ammeters features unusually sensitive TC's; withstand greater overload and cuts power consumption; meet MIL-M-10304; available in $1\frac{1}{2}$", $2\frac{1}{2}$", $3\frac{1}{2}$" and $4\frac{1}{2}$" diameters in ranges up to 0-15 amp RF.—*Meter Div., San Electric Corp., Harlem & Avondale, Chicago 31, Ill.*

For more information circle **383** on inquiry card.

LOG-LINEAR RECORDER

New high-speed HSR-1 Log-Linear Recorder plots logarithm of voltage input level as ordinate and angular



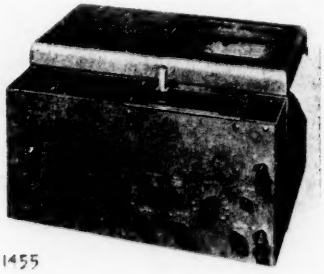
1679

position of a Selsyn as abscissa on standard $8\frac{1}{2}$x11" reproducible paper; records antenna radiation patterns, etc. When used with a square-law detector, it has a 40-db dynamic range with 0.1-db accuracy.—*Rantec Corp., P. O. Box 18, Calabasas, Calif.*

For more information circle **384** on inquiry card.

2-CHANNEL OSCILLOGRAPH

New Type 542 Dynograph two-channel high-performance low-cost oscillograph can be used in many



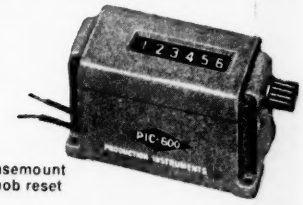
1455

applications for which direct recorders were previously unavailable, for it has 2-millisecond deflection time and a sensitivity of 5 mv/cm.—*Offner Electronics Inc., 5320 N. Kedzie Ave., Chicago, Ill.*

For more information circle **385** on inquiry card.

Endurance RATED

PIC-600 ELECTRIC COUNTERS



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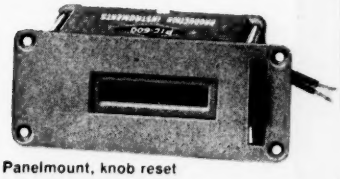

Panelmount, knob reset

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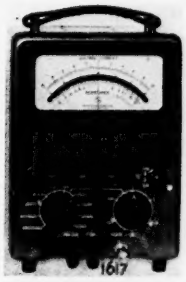
For more information circle **123** on inquiry card.

DIGITAL VOLTMETER

New all-electronic Model 5350 measures dc and ac voltage and resistance to accuracies of 0.5%; features automatic polarity indicator, decimal position indicator lights, accurate oven-controlled reference voltage for calibration, ac-dc switch type probe, and output to drive a digital recorder.—*Berkeley Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif.*

For more information circle **386** on inquiry card.

VOLT-OHM-AMMETER



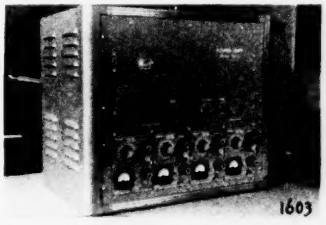
New battery-powered Model 110 E-I-R Meter has 9 voltage ranges from 100 mv to 1000 v, 18 current ranges from 1 microampere to 300 ma. Zero drift is less than 1 mv per hour after a 5-minute stabilization period. Six direct-reading resistance scales provide center readings of 10 ohms to 100 megohms.—*The Belleville-Herem Corp., 638 University Ave., Los Gatos, Calif.*

For more information circle **387** on inquiry card.

electrical-instrument accessories

MEASUREMENT AMPLIFIER

New System D 4-channel galvanometer amplifier package (including power supply (for use with resistive



pickups, thermocouples, etc., will drive even low-sensitivity HF galvanometers and provide "excellent linearity over a wide range of input voltages."—*Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.*

For more information circle **388** on inquiry card.

WIDE-BAND VOLTAGE SUM & DIFFERENCE AMPLIFIER

New Model SND, for use in correlating output signals from strain gages, sound and vibration pickups, etc., features flat frequency response of each channel from 1 cps to 10,000 cps; gain 0.4; sum correct to 2%

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For more information circle **124** on inquiry card.

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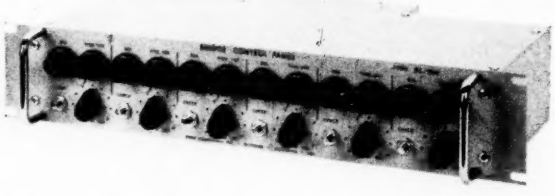
For more information circle **125** on inquiry card.

TYPE BC-266 BRIDGE CONTROL PANEL



This modern bridge control is the most complete, flexible, and compact unit available, as well as one of the most inexpensive. It provides for six channels of from 60 to 1000-ohm gages in any configuration, with shunt or series calibration.

The Owen line of strain gage equipment includes precision single and multi-channel power supplies for "floating" circuitry, and control, balance, indicator, and calibration units —all on modular panels. Custom designs for special applications.

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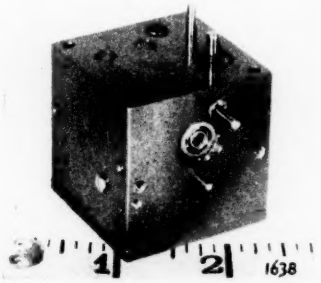
For more information circle **126** on inquiry card.

and output difference signal (for identical inputs) down 40 db; maximum input signal for distorted output 40 v peak to peak. Dimensions 8 x 7 x 12". Leather carrying strap. —*Flow Corp., 85 Mystic St., Arlington 74, Mass.*

For more information circle **389** on inquiry card.

MINIATURE INTEGRATOR FOR CHART RECORDERS

New mechanical analog computing component for use in chart recorders is available in kit form for field in-



stallation in Brown M-H ElectroniK and Bristol Dynamaster. Option: Built-in switch for actuating a remote counter.—*Disc Instrument Co., 12671 Bubbling Well Rd., Santa Ana, Calif.*

For more information circle **390** on inquiry card.

power supplies

TRANSISTOR SUPPLIES

Two new power supplies for use in transistor circuits: (1) closely regulated Model D.6-300B has two outputs, each 0.60 vdc continuously variable, 0-300 ma, electrically separated, floated above ground so that each can be used + or − or both in series. Two volt-&-milliammeters. (2) Precision Model .6-1MB for use in transistor circuit development delivers 0-60 vdc, 0-1 amp; has 1% voltmeter and 1% ammeter; fits 19" rack.—*Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.*

For more information circle **391** on inquiry card.

SILICON RECTIFIER SUPPLY

New Model KM93B provides a stepless controllable output of 0 to 32 vdc with 40-amp continuous-duty full-load rating. Ripple is held to within 0.5%. Safety factor allows continuous operation at 125% of rated current. Cooling is by convection. Voltage regulation from 1/10 load to full-load does not exceed 12% at 32-v output. Panel controls include a power switch, voltage control knob, pilot light, line and load fuses and output binding posts.—*Opad Electric Co., 69 Murray St., New York 7, N. Y.*

For more information circle **392** on inquiry card.

TEST INSTRUMENTS for *LABORATORY/PRODUCTION*

automatic
continuous

NOISE FIGURE measurement

The AIL Type 72 Automatic Noise-Figure Indicator permits rapid and accurate evaluation of parameters that effect receiver noise figure. This equipment finds wide use in the laboratory as well as on the production line. Noise figure can be measured over the 30 to 26,000 Mc range when either an AIL Type 70A Coaxial or an AIL Type 70B Waveguide Gas-Discharge Noise Generator is used. Accuracy of measurement is ± 0.5 db over a 0 to 20 db range. The Noise Generator furnishes an excess noise output of 15.3 ± 0.25 db.

Detailed literature is available on request.

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For more information circle **127** on inquiry card.

1500-AMP SUPPLY

New Model No. MRS2432-1500 tubeless 24-32-vdc @ 1500 amp silicon rectifier type ground-power and missile-checkout power supply has 1% regulation for worst line and load changes.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

For more information circle **393** on inquiry card.

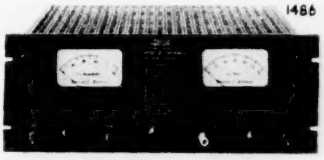
HV DC POWER SUPPLY

New TPC-2 transistorized power converter accepts 12 vdc input and delivers 150 vdc @ 400 ma or 300 vdc @ 200 ma. New units have an efficiency up to 90%; replace dynamotors and vibrator type power supplies. Regulation (1% NL to FL) can be incorporated or is available in a separate unit.—*Southwestern Industrial Electronics Co., 2831 Post Oak Road, Houston 19, Texas.*

For more information circle **394** on inquiry card.

DC POWER SUPPLY

New all-purpose Model G3050 has seven output voltages, 0-300 v @ 0-500 ma; is electronically regulated



to 0.1% for line or load. Line input 105-125 vac @ 50 to 400 cps; ripple 1 mv; transient response 1 ms.—*Dept. G, Universal Electronic Co., 1720 22nd St., Santa Monica, Calif.*

For more information circle **395** on inquiry card.

electrical components

VOLTAGE-DIVIDING RESISTOR

New precision 300 Series Potentiometer, especially suitable for instrumentation, is available with servo bushing or threaded hole mounting; can be obtained with 0.1% independent linearity and with total resistance up to 100 kilohms. Non-linear windings also available. Stainless steel clamp rings allow moisture seal to be inserted between sections, yet per-

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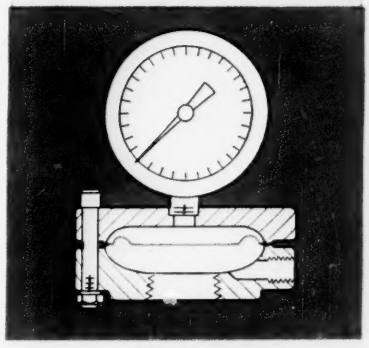

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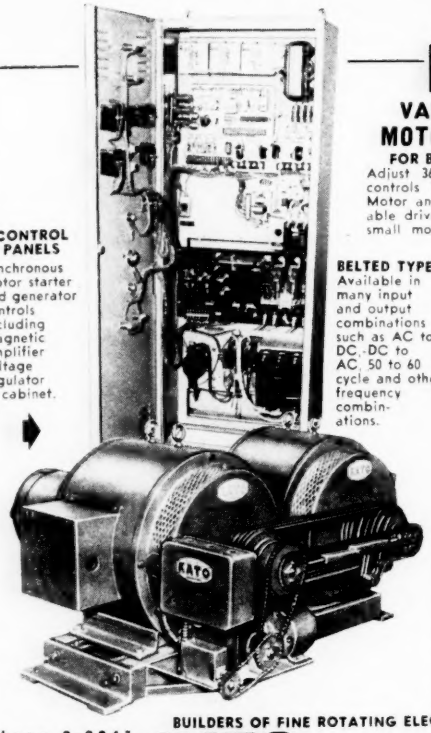

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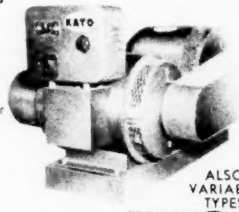

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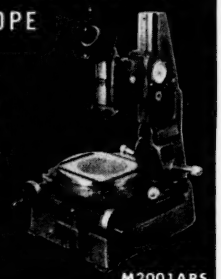

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For more information circle **131** on inquiry card.

NEW INSTRUMENTS

mit easy phasing of individual sections. Up to 9 sections can be mounted on a common shaft.—*Maurey Instrument Corp.*, 7924 *So. Exchange Ave., Chicago 17, Ill.*

For more information circle **396** on inquiry card.

VARIABLE CAPACITORS

New VariVac ceramic-enveloped vacuum-dielectric variable capacitors are available in three size groups.

Maximum engaged capacitance range 10 to 500 uuf and with maximum voltage ratings up to 25,000.—*United Electronics Co., 42 Spring St., Newark, N. J.*

For more information circle **397** on inquiry card.

LARGE GERMANIUM JUNCTION

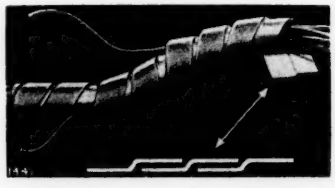
New 500-amp germanium power junction (largest commercially-available single-crystal junction) has a large active area, whence a low current density in crystal. Conservative rating provides an added capacity in all cases of over-temperature and overload.—*International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.*

For more information circle **398** on inquiry card.

electromechanical components

TEFLON SPIRAL COVER

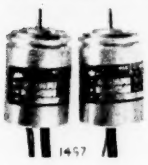
New type of wire-harness product overlaps itself 100%, forming a double cover with insulating qualities almost



equal to solid jacketing. Non-inflammable Teflon for high heat applications (200°C); 0.040" wall; six diameters from ¼" to 1½"; various lengths.—*Illumitronic Engineering, 680 E. Taylor, Sunnyvale, Calif.*

For more information circle **399** on inquiry card.

TRANSMITTER AND RECEIVER



New more-adaptable Size- 10 115/11. 8-v 400-cps transmitter-synchro and receiver-synchro features elimination of stepdown transformer, whence reduction of system size and weight. System has torque gradient of 2900 mg mm/deg.—*John Oster Mfg. Co., Avionic Div., 1 Main St., Racine, Wis.*

For more information circle **400** on inquiry card.

SUBMINIATURE SWITCH

New Type EA-1 comprises 5-amp MIL-type USM5 switch enclosed in corrosion-resistant aluminum housing, embedded in epoxy resin. Seal permits movement of operating pin yet keeps out oil, dirt and moisture.—*Unimax, Switch, Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.*

For more information circle **401** on inquiry card.

CLOSURES

New precision drawn closures of Mu metal are available in round, square and rectangular shapes, in economical standard sizes, and in cases to customers' specifications. Some standard shapes and sizes carried in stock.—*Hudson Tool & Die Co., Inc., 18 Malvern St., Newark 5, N. J.*

For more information circle **402** on inquiry card.

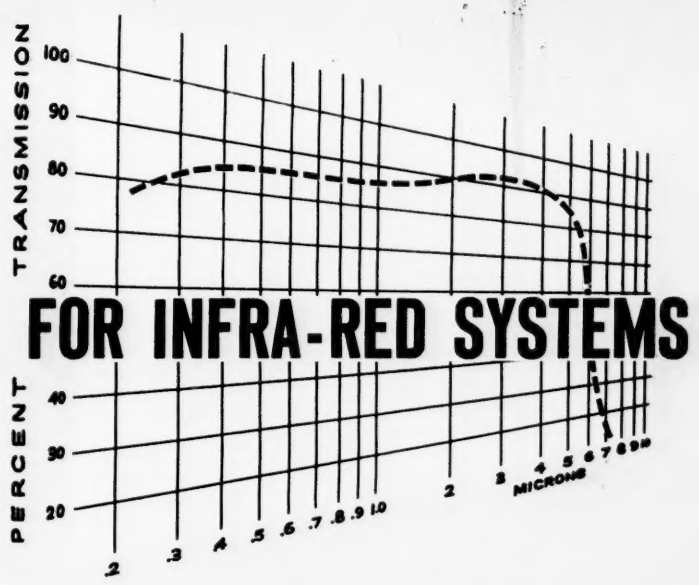
SLIP-RING ASSEMBLIES

New Model R Slip Ring Assemblies have silver conductors and Pyrex glass inserts for circuit interruption embedded in a fiberglass-reinforced matrix of nonnutrient epoxy; operate at temperatures from −60°F to 160°F and at altitudes from sea level to 60,000 ft; meet vibration, shock, and other requirements of MIL-E-5272A.—*Servonic Instruments, Inc., 640 Terminal Way, Costa Mesa, Calif.*

For more information circle **403** on inquiry card.

DC SOLENOID-MAGNET

New 115-vdc Model 200 features 1.4-lb force over ¾" plunger travel; operating current 53 ma and drop-



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For more information circle **132** on inquiry card.

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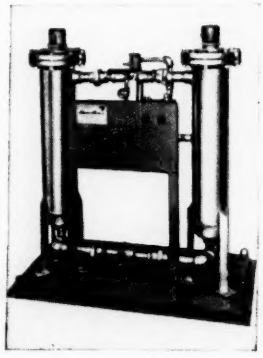

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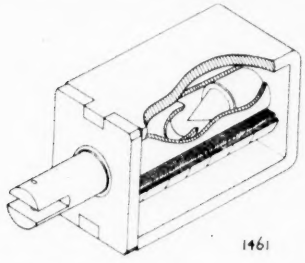
NEW INSTRUMENTS

out current 12 ma; coil resistance 2000 ohms (other values available);



maximum continuous operation 3 hr. —*Parks Electronics Corp.*, 12311 *Bothell Way, Seattle* 55, *Wash.*

For more information circle **404** on inquiry card.

MERCURY-CONTACT RELAY

New Electronic Relay Model #4, claimed to be "the most important advance in the design of highly sensitive electronic relays for the control of relatively large amounts of power," incorporates new RotoRelay employing a sealed 35-amp mercury switch tube which is magnetically tilted to open or close.—*Manostat Corp.*, 20-26 *N. Moore St., New York* 13, *N. Y.*

For more information circle **405** on inquiry card.

FUSED MERCURY RELAYS

New fused Mercury Plunger Relays are added to maker's line. Illustrated: EMF-1 for loads up to 35 amp at 115 vac; others are of 2- and 3-pole construction, and for loads up to 60 amp at 115 vac. In these, relays and fuses are Bakelite-panel mounted.—*Elbert Electronics Corp.*, 212-26 *Jamaica Ave., Queens Village* 28, *N. Y.*

For more information circle **406** on inquiry card.

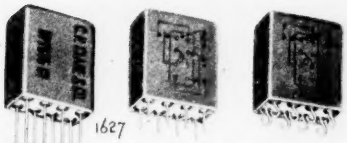
PLUG AND JACK

New No. 2265 jack maintains gripping power by a specially-designed compression spring used with

a floating key. New No. 2225 plug is available with either a red or black nylon jacket insulation (or uninsulated, No. X2201-2). Will accept up to No. 20 wire.—*Thermionic Corp.*, 445 *Concord Ave., Cambridge* 38, *Mass.*

For more information circle **407** on inquiry card.

SEALED RELAY

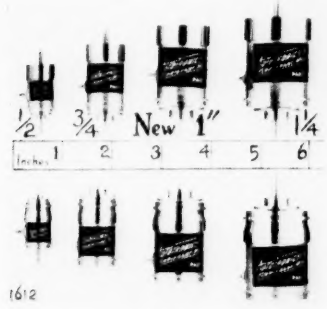


New Type F postage-stamp-size hermetically-sealed relay, rated for ambient temperatures from —65 C to 125 C, withstands 50-G shock for 11 milliseconds. Pickup time 3.5 ms nominal; drop-out time 1.5 ms nominal. Contact rating 3 amp resistive at 28 vdc or 115 vac.—*C. P. Clare & Co.*, 4101 *Pratt Blvd., Chicago* 45, *Ill.*

For more information circle **408** on inquiry card.

CLUTCH-AND-BRAKE

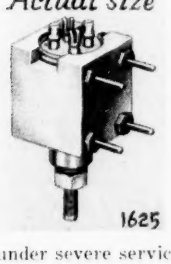
New 1" size added to maker's line of subminiature electromagnetic clutch and brake units is available



in seven models with output shafts on either or both ends, whence 21 variations.—*Autotronics Inc., RT1, Box 812, Florissant, Missouri.*

For more information circle **409** on inquiry card.

RF SHIELDED COIL FORM



New completely-shielded coil form assembly using internal powdered-iron components of unique design is said to be ideal for I-F strip work requiring ease of tuning, compactness, and dependability under severe service conditions; has a positive compression-type tuning core lock.—*Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

For more information circle **410** on inquiry card.

SIZE 18 SERVOMOTOR

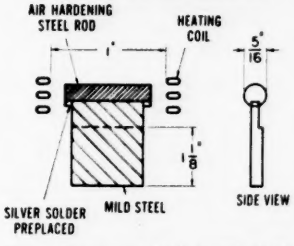
New Model 18 SM 490 features high stall torque, low rotor inertia and instantaneous acceleration;

The Lepel Line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

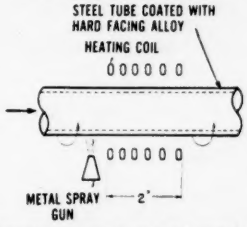
TYPICAL INDUCTION HEATING APPLICATIONS

SIMULTANEOUS HARDENING and BRAZING

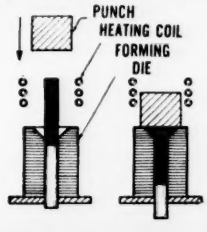


The machined and finished rod of air-hardening steel is simultaneously hardened and brazed to a mild-steel tab. Use of a purified hydrogen atmosphere and a high temperature brazing alloy permits successful hardening of alloy steels without discoloration and scaling even in the absence of flux.

DIFFUSION BONDING OF SPRAYED METAL COATINGS



Corrosion or wear resistant metal coatings sprayed on metal surfaces can be improved by heating to achieve alloying by diffusion. The drawing shows a typical arrangement for processing steel tube sprayed with hard facing alloy. Long tubes may be progressively sprayed and heated.



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Uniform and rapid heating of high strength alloys (alloy steels, titanium, etc.) aids in upsetting and forming operations and also minimizes oxidation and embrittlement.

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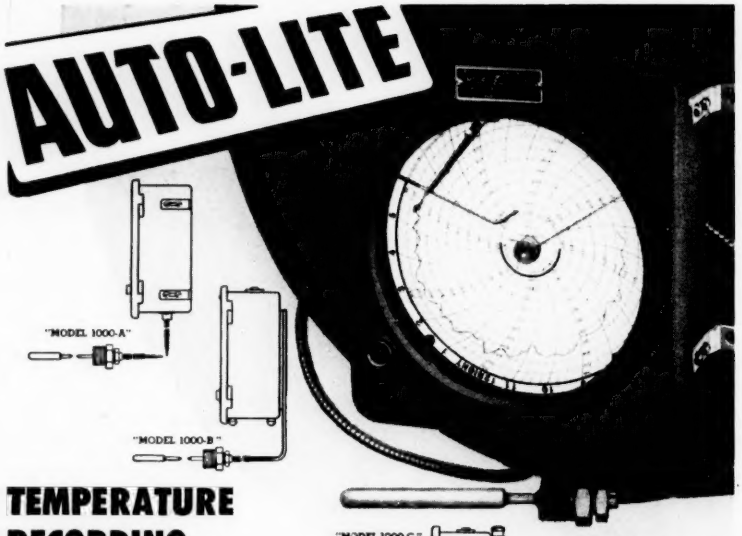

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NEW INSTRUMENTS

weighs 12 oz, measures 1¾" dia by 2½" long. Extensive use of Teflon wire and insulating material permits rated continuous operation up to 200°C. Fixed windings operate on 115-v 400-cps or can be wound for any standard carrier supply; control windings can be custom wound for input from various amplifiers; standard models can be provided with dc cancellation in their control windings. —*Beckman/Helipot Corp., Newport Beach, Calif.*

For more information circle **411** on inquiry card.

mechanical components

EXPERIMENTAL GEAR SET

New Servo-Speed/Torque-Unit, for use with maker's Servo-Kit and other servo equipment, is a complete set of change gears which enables user to select any one of six output speed and torque values. Two models, each with its Barcol motor and provision for coupling a ⅜" bushing-mount pot directly to output shaft.—*The Servo-Systems Co., 55 Meeker Ave., Newark 12, N. J.*

For more information circle **412** on inquiry card.

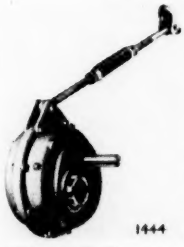
RIGHT ANGLE DRIVE

1451

New Blue Chip right-angle drive, intended primarily for remote operation of tuning capacitors, resistors, etc., will tolerate intermittent high-speed operation (up to 500 rpm) with loads up to 100 oz-in. Unloaded running torque less than 2.5 oz-in.—*National Company, Inc., Malden 48, Mass.*

For more information circle **413** on inquiry card.

GEAR REDUCER



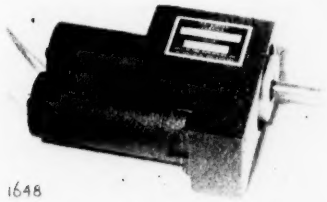
1444

New shaft-mounted gear reducer obviates need for motor bases, rails, supporting structures and flexible couplings; eliminates alignment problems; can be mounted at any angle; makes possible infinite speed ratios through use of variable-speed pulleys or by changing sheaves, sprockets or prime mover speed. Models in stock include 9 single and 9 double reduction types; fractional to 120 hp; output speeds from 8 to 425 rpm.—*Lovejoy Flexible Coupling Co., 4900 W. Lake St., Chicago 44, Ill.*

For more information circle **414** on inquiry card.

MINIATURE DIFFERENTIALS

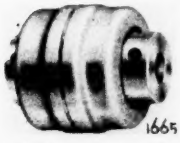
New custom-built differentials feature high torque characteristics and smooth speed variation through zero



rpm, yield algebraic sum or difference of two speeds as rpm of output shaft. Each contains two ac or dc motors and a precision gearing unit.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton 4, Ohio.*

For more information circle **415** on inquiry card.

HIGH-RATING COUPLINGS



New Metro-Flex couplings will easily handle angular misalignment of driving and driven shafts up to 5°, parallel offset to as much as 0.01" and axial end play up to 0.09"; assure high torsional rigidity and constant rotational velocity, transmit torques up to 150 oz-in; permit speeds to 10,000 rpm, and minimize backlash.—*Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.*

For more information circle **416** on inquiry card.

BELLOWS COUPLING

New Type T9 stainless steel zero adjustable bellows coupling allows precision adjustment on sensitive

shafts; is designed for 360° continual rotation and adjustment.—*PIC Design Corp., 477 Atlantic Ave., East Rockaway, N. Y.*

For more information circle **417** on inquiry card.

PISTON SEAL

New Variable-area Diaphragm converts fluctuating pressures into energy sources for stable precise control, obviates need for pressure regulators in many cases. As a piston seal it is self-compensating and operates as a ratio-controller: its effective area changes in a predetermined way with stroke. When incorporated

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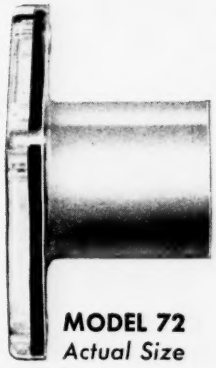

MODEL 72
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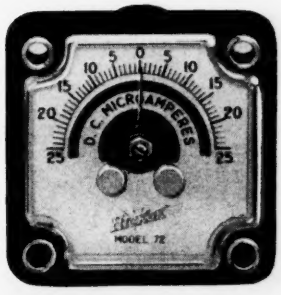
This unusual instrument development meets all the requirements of MIL-M-10304A as applicable, and is available in all standard DC ranges.

The completely self-shielded 180 degree arc-angle movement features a new type pivot with a new reinforced jewel holder and other construction advantages designed to withstand exceptionally high impact and vibration without impairing the accuracy or functioning qualities of the meter.



ALSO AVAILABLE

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For more information circle **138** on inquiry card.

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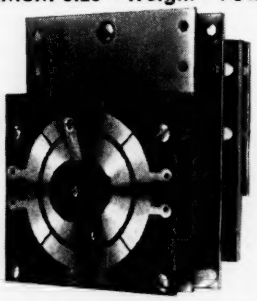
MINIMUM Size - Weight - Power Drain

Brailsford AGC Timers Are Unmatched In These Basic Requirements



Model AGC

If You Have A Timing Problem Where Size, Mass and Power Drain Are Critical Read These

SPECIFICATIONS

Number of decks—1-4 • Speed regulation—±1.0% at 50% voltage shift
Size—1¾" x 2¼"—depth depends on number of decks
Segments per deck—2-8 for stock units.
Special commutators to order for a nominal tool charge.
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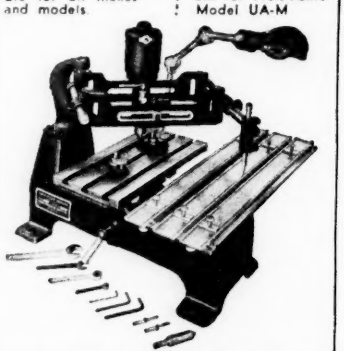

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For more information circle 141 on inquiry card.

NEW INSTRUMENTS

in a valve motor, it gives smooth stable control over varying pressure changes because actuating sensitivity is inversely proportional to loading pressure.—*Bellofram Corp., Burlington Mass.*

For more information circle **418** on inquiry card.

TUBING BENDING CLIP

New clip holds a permanent 90° bend (1" radius) in ¼" OD plastic tubing; saves installation time; is

manually attached by simple snap-on procedure; also easily removed and placed elsewhere.—*The Polymer Corp. of Penna., Reading, Pa.*

For more information circle **419** on inquiry card.

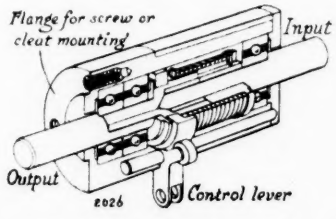
O SEAL FITTINGS

New fittings, consisting of a straight thread O Seal Male Connector and O Seal Adapter, were developed for both high- and low-pressure systems and for critical applications where even the most minute leak cannot be tolerated. They permit (1) various fittings combinations with use of standard fittings; (2) high vacuum seal. Sizes ⅛" to 1".—*Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio.*

For more information circle **420** on inquiry card.

CLUTCHES AND BRAKES

Five new high-speed miniature integrally-packaged spring-clutch components are particularly adaptable



to computers, automatic controls and servo systems. Illustrated: Dykor Model A-300 Mechanical Amplifier Clutch, available in normally-off or normally-on operation; response time 1 millisecond in tests up to 6300 rpm. Also available: Model A-100 Mechanical Pulse Amplifier Indexing Clutch, Model S-100 Clutch, Model A-100 CP Clutch Pack, and Model A-500 Mechanical Amplifier Brake.—*Digitronics Corp., Albertson Ave., Albertson, L. I., N. Y.*

For more information circle **421** on inquiry card.

valves

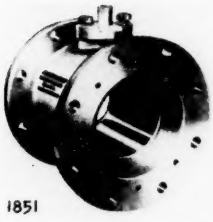
SOLENOID VALVE

New 2-way normally-closed Model 291, available in brass or stainless steel, was designed for use in tight

equipment corners; can operate in any position.—*A P Controls, 2450 N. 32nd St., Milwaukee 45, Wis.*

For more information circle **422** on inquiry card.

BALL VALVES



New 6" and 8" sizes, added to maker's line of Double-Seal Ball Valves, are available in stainless steel, carbon steel, bronze or aluminum; seats and seals in Teflon and synthetic rubbers; feature quarter-turn positive shut-off; hand or air operated; no lubrication ever required.—*Jamesbury Corp., 45 New St., Worcester, Mass.*

For more information circle **423** on inquiry card.

miscellaneous

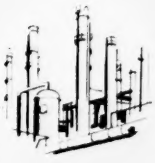
DEHUMIDIFIER

New Model 105 Dryomatic automatically-regulated dual-tower unit uses silica gel as drying medium; maintains humidities down to 10% in rooms up to 35,000 cu ft over a wide range of temperatures; also provides low-dew-point air for processing applications; can remove 50 lb of water per 24 hours. Silica gel is regenerated automatically.—*Dryomatic Corp., 806 N. Fairfax St., Alexandria, Va.*

For more information circle **424** on inquiry card.

DUPLICATOR PAPER ROLL FOR TELETYPEWRITER

New Azograph master roll permits making multiple copies of teletypewriter messages without extra work. It is put on teletypewriter in place of conventional roll of paper. Receiver of message simply detaches wanted portion, puts it on duplicator, and runs off his copies. Azograph rolls are available either in single-ply, pro-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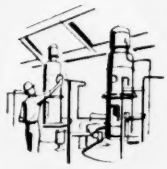
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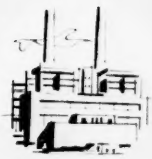
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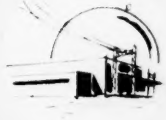
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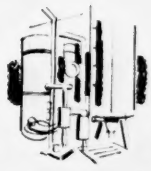
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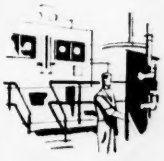
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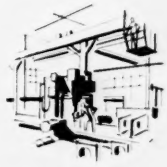
LABORATORIES AND PILOT PLANTS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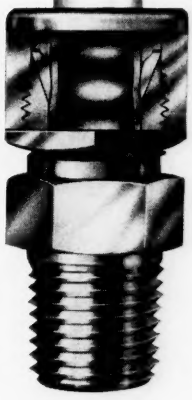
TUBE FITTINGS



In use wherever top performance is demanded. Swagelok Tube Fittings provide a leakproof, torque-free seal. Your Swagelok Specialist will welcome the opportunity to work with you on your particular fitting requirements. For information, write Dept. B-2.

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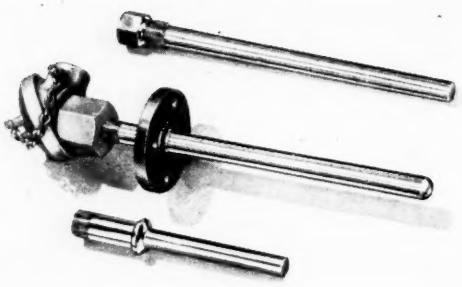

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With T-E's thermocouple assemblies you get: (1) choice of an extremely wide variety; (2) carefully pre-tested quality; (3) simplified ordering – one code number for a complete thermocouple assembly.

Thermocouples – Wire type from 20 to 6 gage. Ruggedly constructed, sensitive in performance. Available with fiberglass or various types of ceramic bead insulation. Calibrated in Iron-Constantan, Copper-Constantan or Chromel-Alumel.

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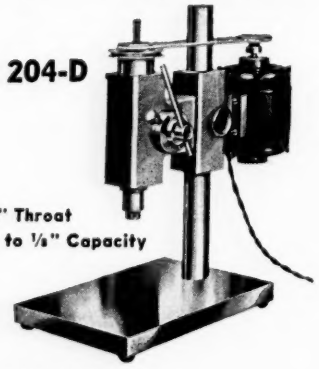
Precision drilling made easy!

The *Phillips & Hiss*

204-D



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Sensitive Speed Control: Foot operated, leaves both hands free.

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MICO

New Heavy-Duty 2 & 3 Dimensional Engraver

FOR:
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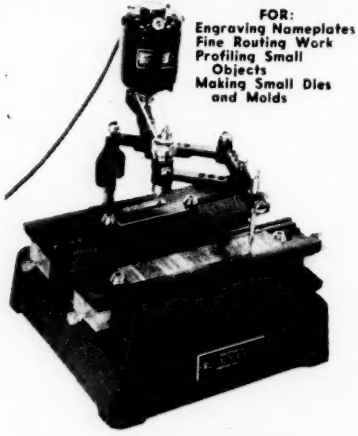

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viding a master only, or in combination with carbon sets so that "flash" copies are available immediately. Continuous-form Azograph masters are available also.—*A. B. Dick Co., 5700 W. Touhy Ave., Chicago 31, Ill.*

For more information circle **425** on inquiry card.

KEYBOARD-PERFORATOR

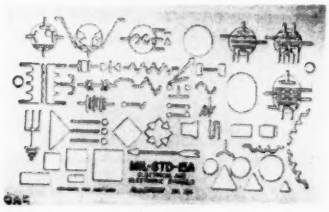
New Model KP has 32 characters, any of which is automatically encoded for 5-hole punched tape. After

striking key corresponding to desired character, space bar is pressed, causing perforator to provide a corresponding code hole in tape and operating a counter. KP permits automatic reperforation (duplication) when used with a 5-channel reader, and editing with new information. Memory unit and reader are also available.—*Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N. Y.*

For more information circle **426** on inquiry card.

TEMPLATES

New No. 314 MIL-std-15A electrical and electronic symbols template, de-



signed for 0.1" grid paper, is 7" x 4". ★No. 315 is similar but is for 0.25" grid.—*Rapidesign, Inc., P.O. Box 429, Burbank, Calif.*

For more information circle **427** on inquiry card.

OIL-TIGHT PILOT LIGHTS

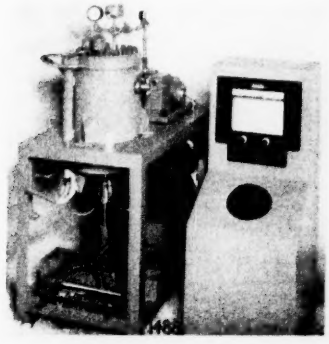
New series of Oil-Tight Indicator Lights have built-in resistors for use with neon glow lamps; mount in ⅛"

clearance hole. Choice of lenses: "fluted" type (shown), or plain, unfrosted, or with frosted back, seven lens colors. Screw or soldering terminals.—*Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.*

For more information circle **428** on inquiry card.

CRYSTAL-GROWING FURNACE

New high-temperature high-pressure furnace operates at 3300°F at 3000 psig; permits observation and



movement of workload for controlled solidification at full temperature and pressure; is instrumented to hold ±1 F; is suitable for work on single-crystal formation for CdS, etc.—*Vacuum Specialties Co., Inc., 34 Linden St., Somerville, Mass.*

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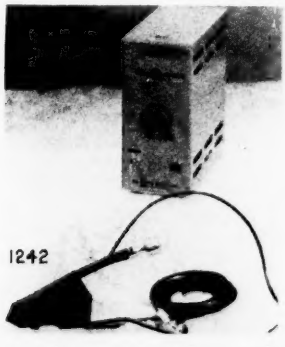
NOISE-OPERATED RELAY

New silenced Model 320 S Noise-Operated Relay comes ready to plug-in (no need to rig up a makeshift);

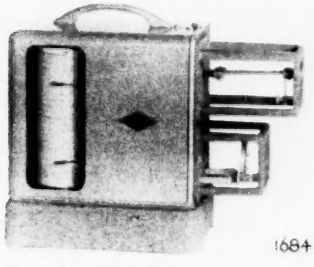


operates from a microphone pick-up; features adjustable sensitivity.—*Hunter Mfg. Co., Iowa City, Iowa.*

For more information circle **430** on inquiry card.

HYGROTHERMOGRAPH

New ruggedized indoor-outdoor Model HGS-HYT-1 features hygrometer accuracy guaranteed repeatable



within 3% RH; operating range 15% to 95% RH between 32°F and 130°F;

General Insurance of America tested

. . . *and picked* audiotape

Chief Engineer cites type EP Audiotape for "dust-free coating, uniform signal output . . . high precision"

WHEN General Insurance Company of America bought four Electrodata tape transports 18 months ago, they knew one thing: their computing system should have the finest magnetic recording tape available. It was decided that the best way to make the final decision was to test.

The tests started immediately. Every nationally known make of magnetic recording tape was used on the transports for at least a month. The result was clear; type EP Audiotape was chosen.

As D. G. Jessup, Chief Engineer of General's Computing Department, wrote in a letter to Audio Devices, "To obtain the optimum reliability and performance from our computing system we need the oxide dust-free coating, uniform signal output level correct in both directions of travel, and high precision reels which you supply. Keep up the good work!"

The extra precision Mr. Jessup found in type EP Audiotape is not a matter of chance. Rather it is the result of meticulous selection and inspections that start when the master rolls of base materials are examined for uniformity. The quality control is continued through the manufacturing process, ending only when the tape is checked by a defect counter, rejects discarded, and the defect-free tape packed in sealed containers. This high standard of control is backed up by our guarantee that every reel of type EP Audiotape is defect-free.

For more information on type EP AUDIOTAPE, write for Bulletin T112A. Write to Box TI, Audio Devices, 444 Madison Ave., New York 22, N. Y.

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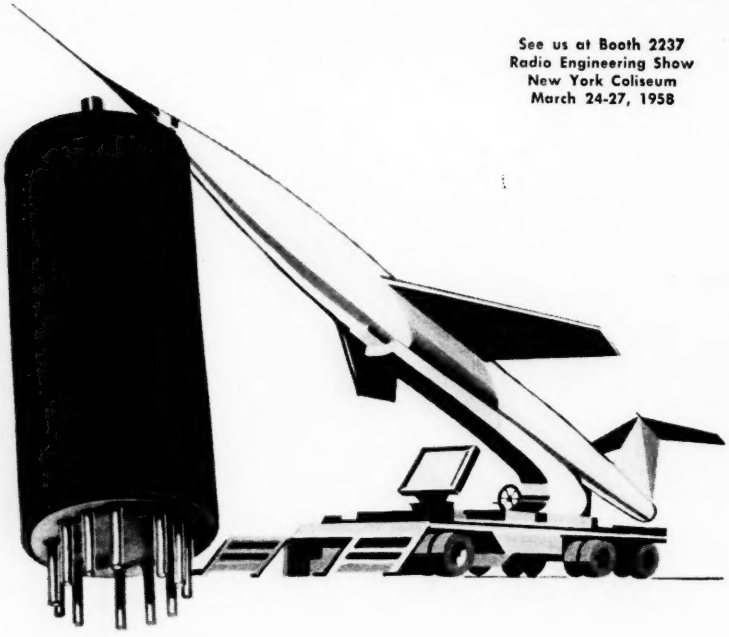

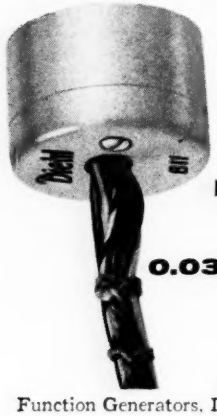

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74% with T.F.E. less than	0.020%
22% with T.F.E. from	0.020% to 0.025%
4% with T.F.E. from	0.025% to 0.03%

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For more information circle **147** on inquiry card.

NEW INSTRUMENTS

temperature accuracy guarantee 1 F from 0°F to 100°F; jeweled clock chart drive precluding loss of record in case of electric power outage; field-adjustable pen zero.—*Serdex, Inc.*, 12 *Bowdoin Square, Boston* 14, *Mass.*

For more information circle **431** on inquiry card.

last-minute items

Terminal Pinserter for semi-automatic insertion of electronic terminals features quick complete changeover from one terminal pin to a different size; production rate up to 30 per minute.—Aidlings, Inc., 1613 E. New York Ave., Brooklyn 12, N. Y.

For more information circle **432** on inquiry card.

Freezing-point Depression Apparatus provides a rapid, dependable inexpensive method for determining osmotic pressure, molecular weights, etc.—American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.

For more information circle **433** on inquiry card.

Teaching Microscopes. Series ST, "the closest thing to a professional laboratory microscope ever developed for school use, yet the price is among the lowest."—Bausch & Lomb Optical Co., Rochester 2, N. Y.

For more information circle **434** on inquiry card.

Frequency Measurement. Meterodyne equipment extends frequency measuring range of maker's 10-Mc EPUT meters to over 220 Mc.—Berkeley Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif.

For more information circle **435** on inquiry card.

Bonding-agent Syringe. New Helix Disposable Syringe ($3.50 per doz) quickly applies bonding agents, potting compounds, etc., without waste or drip.—Carl H. Biggs Co., Inc., Dept. 357, 2255 Barry Ave., Los Angeles 64, Calif.

For more information circle **436** on inquiry card.

Ultrasonic Cleaning. Model R-50 includes ultrasonic generating units, a heater, temperature control and filtration and recirculation systems.—Branson Ultrasonic Corp., 37 Brown House Rd., Stamford, Conn.

For more information circle **437** on inquiry card.

Color Film Developing Tanks. Wyre Coil tanks and reels are all-stainless-steel.—Burke & James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.

For more information circle **438** on inquiry card.

35mm Camera. Acon Model IIL with film advance lever and lens coupled to rangefinder is said to bring more quality features to low-priced field.—Burke & James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.

For more information circle **439** on inquiry card.

For Printed Circuits. CA 0186 MS type receptacle is designed to mate with from 1 to 4 printed circuit boards.—Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

For more information circle **440** on inquiry card.

Contact Crimping Tool. HXT-1, for use in crimping contacts for high-vibration applications, features ratchet which prevents release of handle until complete crimping force is exerted.—Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.
For more information circle **441** on inquiry card.

Converter delivers 2000 watts ac from 32-volt storage battery. Four-pole design permits an armature operating speed of only 1800 rpm, whence maximal life and quiet operation.—Carter Motor Co., 2711 A W. George St., Chicago 18, Ill.
For more information circle **442** on inquiry card.

High-frequency Power Transistor (to 20,000 cps) replaces vacuum tubes in many functions, will find use in reducing size of components.—Clevite Transistor Products, Waltham, Mass.
For more information circle **443** on inquiry card.

Silicon Junction Diode features ultra-fast recovery time, high forward conductance (typical: 50 ma at 1.5 v), extremely low reverse current and freedom from thermal runaway at high voltage and 150°C.—Clevite Transistor Products, Waltham, Mass.
For more information circle **444** on inquiry card.

Tape Punch Input Unit. Model CCV-40 mounts directly on maker's motorized Tape Punch. Integral unit accepts digital input data, programs desired format, and scans digital information into tape punch.—Coleman Engineering Co., Inc., 6040 W. Jefferson Blvd., Los Angeles 16, Calif.
For more information circle **445** on inquiry card.

DBM/DBA Meter. Model 11A, for telephone test and maintenance applications, measures signal and noise levels in AF range. Its unusual sensitivity permits measurements of less than zero DBA.—Consolidated Electrodynamics Corp., Alectra Div., 325 N. Altadena Drive, Pasadena, Calif.
For more information circle **446** on inquiry card.

Precision Strain-gage Load Cells provide up to 250% greater output, whence minimized interference from stray signals; feature temperature insensitivity. Nine capacities 500 to 200,000 lbs.—Cox & Stevens Electronic Sales Div., Revere Corp. of America, Wallingford, Conn.
For more information circle **447** on inquiry card.

Digital Strain Gage Indicator accepts inputs from resistance pickups via null-balance servo; reads out digitally in true units.—Datran Electronics, Manhattan Beach, Calif.
For more information circle **448** on inquiry card.

Polarity Tester. Model R rapidly determining polarity of all types of transformers; withstands worst service conditions.—J. W. Dice Co., Englewood, N. J.
For more information circle **449** on inquiry card.

Magnetic Clutch-Brake. D-102, size 18, operates wearlessly for several million cycles of engagement and disengagement under full torque load.—Dynamic Instruments Corp., 59 New York Ave., Westbury, L. I., N. Y.
For more information circle **450** on inquiry card.

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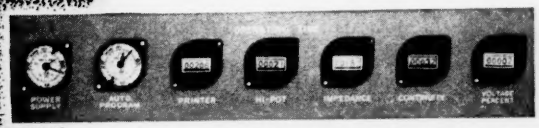
You, too, can afford the space to keep track of time! From now on, these really small (1¼") Elapsed Time Indicators will keep company with the best of Electronic Miracles.



The illustration shows how the operating time of various sections of an electronic console can be monitored.

The dial type units read up to 2,500 hours in one hour increments, while the digital type units read up to 9999.9 hours in one-tenth hour increments. Designed for military applications, these 4½ ounce units can save valuable panel space in industrial and electronic applications.

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For more information circle **148** on inquiry card.

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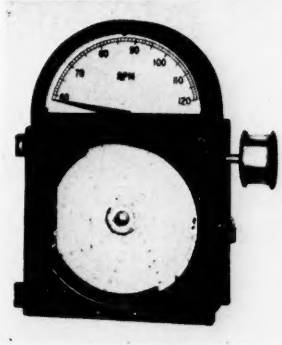

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WILMAD

For more information circle **151** on inquiry card.

NEW INSTRUMENTS

use with special-type moving-mirror galvanometer oscillographs.—Eastman Kodak Co., Rochester 4, N. Y.
For more information circle **451** on inquiry card.

Low-cost Astronomical Telescope has 4½" mirror; 6-power finder telescope; real equatorial mount; mounted Barlow lens giving powers of 120X and 270X.—Edmund Scientific Co., Barrington, N. J.
For more information circle **452** on inquiry card.

Corrosion-resistant Wax-lined Cans are available in any size or shape with opening of ⅜" or larger. Small or large runs are available.—George D. Ellis & Sons, Inc., American & Luzerne Sts., Philadelphia 40, Pa.
For more information circle **453** on inquiry card.

General-purpose Galvanometer for recording and indicating applications features 0.5-ma sensitivity; 40° full-scale rotation; ½-second full-scale response; variable damping.—Engineering Enterprises Inc., 1200 18th St., N. W., Washington 6, D. C.
For more information circle **454** on inquiry card.

Test Chamber. New Model DI-3 covers temperatures from −100°F to 300°F; features low-mass Nichrome heating unit and dry ice cooling. Standard test space is 18" cube.—Environmental Equipment Co., 369 Linden St., Brooklyn 27, N. Y.
For more information circle **455** on inquiry card.

Push-Pull All-magnetic Thyratron Grid Drive is the first designed especially for servo applications; provides up to 15 kw.—Fairfield Engineering Corp., 934 Hope St., Springdale, Conn.
For more information circle **456** on inquiry card.

Purge Meter features removable snap-in tube and fittings, corrosion-proof fibre-glass body, 3" scale length, and snap-on protective Lucite shield.—Fischer & Porter Co., 578 Jacksonville Rd., Hatboro, Pa.
For more information circle **457** on inquiry card.

Electrical Contact Tapes, silver-cadmium-oxide clad contact material allows lower-cost contacts, also automatic assembly which provides savings in assembly costs.—General Plate Div., Metals & Controls Corp., Attleboro, Mass.
For more information circle **458** on inquiry card.

Viewfinder TV Camera Chain. Model PD-250, for classroom or studio use, is designed for one-man operation.—General Precision Laboratory Inc., Pleasantville, N. Y.
For more information circle **459** on inquiry card.

Capacitors. New Syncap glass-encapsulated hermetically-sealed high voltage plastic-film capacitors are available in values from 100 mmfd to 1 mfd; 600 to 20,000 vdc.—H. D. & K. Labs., Inc., P. O. Box 172, Shelburne Falls, Mass.
For more information circle **460** on inquiry card.

School Microscope. Bleeker K, of compact ¾ size, has six combinations of eyepieces and objectives offering final magnifications from 32x to 375x.—Karl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.
For more information circle **461** on inquiry card.

35mm Camera. Alpa Alpagon coated 35mm f/3.5 lens for Alpa 35mm single-lens reflex camera has automatic diaphragm, 62° angle of view.—Carl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.

For more information circle **462** on inquiry card.

High Vacuum Bell Jar Unit for vacuum evaporation of either reflective or non-reflective coatings; 3 sizes with 520, 640 or 1800 cfm fractionating diffusion pump.—High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.

For more information circle **463** on inquiry card.

Conductivity Cells, new armored glass flow type for chemical processing and demineralized water industries; wide range of cell constants.—Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.

For more information circle **464** on inquiry card.

Phase Meter. Model 200AB Phasor compensates for noise and harmonic voltages; measures phase angles to 0.01°.—Industrial Test Equipment Co., 55 E. 11 St., New York 3, N. Y.

For more information circle **465** on inquiry card.

Motor Generators and Rotary Converters. Improved units meet specialized performance demands of military and civilian original equipment manufacturers and government subcontractors.—Kato Engineering Co., Mankato, Minn.

For more information circle **466** on inquiry card.

Sensitive Relay. Series AS Telephone Relay features 2 microswitches, resistances up to 75,000 ohms, dc operation. Maximum 100 milliseconds release is available.—Kurman Electric Co., 191 Newel St., Brooklyn, N. Y.

For more information circle **467** on inquiry card.

Circular Saws, high-speed extra-fine-tooth for instrument work, are 30 mm dia, thicknesses from 0.10 to 1.00 mm by increments of 0.05 mm.—Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 7, Calif.

For more information circle **468** on inquiry card.

Load Control. New MEK-2129 is especially suited for control of feed devices on crushing and grinding machines; allows automatic restarting.—Machinery Electrification, Inc., 56 Hudson St., Northboro, Mass.

For more information circle **469** on inquiry card.

Office Machine. New Model 60 Master Addresser writes names and addresses or other repetitive forms up to 100 times from a single typing. Paper master can be filed.—Master Addresser Co., 6500 W. Lake St., Minneapolis 26, Minn.

For more information circle **470** on inquiry card.

Gravity Convention Ovens. Models 5720, 5715, and 5710, for industrial and educational uses, feature thermostatic control to 1 C° from 30°C to 260°C; corrosion-resistant interior and shelves.—National Appliances Co., 7634 S. W. Capitol Hwy., Portland 19, Ore.

For more information circle **471** on inquiry card.

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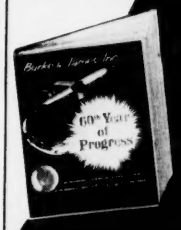

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- CAMERAS—from Sub-Miniature to HUGE CUSTOM BUILT
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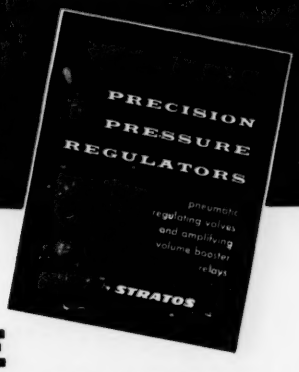

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PRESSURE REGULATORS

The facts you need on a complete range of pneumatic pressure regulating valves and volume boosters. Here is your guide to a series of pilot-operated and direct acting regulators—in pipe sizes from ¼ to ⅜ and ¾ NPT...in supply pressures up to 250 psi. Fact-filled pages spell out the full story: characteristics • pressure ranges, ratios • applications—for 16 different models including motor operated and lever set types.

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Route 109, West Babylon, N. Y.

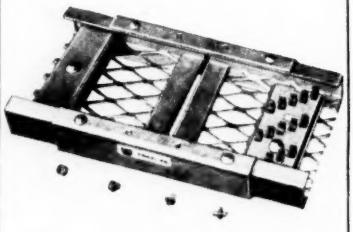
A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

For more information circle **154** on inquiry card.

SPECIFY

P.W

for Supporting Instrument Tubing



P-W Manufactures a complete trough system with channel connectors. Drive rivets are used for quick assembly.—Extension Connectors eliminate field cutting—Adjustable connectors for any change in direction or elevation—I Section for long spans—Tube Clips—Cushion Clamps

Raceway to support a limited number of tubes with connectors, elbows, tees, etc.—Bulkhead Bar. P-W systems are available in widths from 1" to 24" and in lengths from 1' to 16'.

Twist-Rack

The Structure To Support Tubetrof . . . Cabletrof . . . Shelving . . . Conduit . . . Cables . . . Pipe, Etc.

Write today for Bulletin 656-G

P-W INDUSTRIES, INC.
Duncan & Melrose Sts.,
Philadelphia 24, Pa.

(Representatives to serve you!)

For more information circle **155** on inquiry card.

and regulation.—Nelson Instrument Co., 607 Howard St., Evanston, Ill.
For more information circle **472** on inquiry card.

Spectrometer-Radigraph. Mobile Model C-2600 provides high counting accuracy with minimum patient dosage; comprises a C-2910 single-chassis spectrometer, a scintillation probe with sensitive 2x2" NaI crystal, and a console housing with counterbalanced holder for accurate placement.—NRD Instrument Co., 9842 Manchester Rd., St. Louis 19, Mo.
For more information circle **473** on inquiry card.

Permanently Marking Thermometers. New method has been developed by the P.M.T. Committee, composed of thermometer manufacturers. Information, specs and quotations obtainable from Fairfax, Inc., Advertising, 270 Madison Ave., New York 16, N. Y.
For more information circle **474** on inquiry card.

Lathe-Cut Rings, synthetic rubber, rectangular cross-section, for sealing applications, available in many compounds.—Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.
For more information circle **475** on inquiry card.

Teflon Reuseable Tubing Connectors, for lab glassware and equipment applications involving high temperatures, strong solvents, or corrosive materials, are easier to use than many other types.—Penna. Fluorocarbon Co., Inc., 1115 N. 38th St., Philadelphia 4, Pa.
For more information circle **476** on inquiry card.

Instrument Panel Clocks, Type ED, waterproof and shock-resistant, are made and finished to MIL specs (shock resistant, etc.)—Pic Design Corp., Inc., 477 Atlantic Ave., East Rockaway, N. Y.
For more information circle **477** on inquiry card.

Hi-Speed Chromatograph employs centrifugal force, cuts normal chromatographic separation time from hours or days to five minutes. Its separations equal classical resolutions.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.
For more information circle **478** on inquiry card.

Miniature Pressure Pickups incorporate voltage-dividing resistors of infinite resolution, are available in ranges between 15 and 300 psia, psid & psig.—Rahm Instruments, Div. of American Machine & Metals, Inc., 65 Rushmore St., Westbury, L. I., N. Y.
For more information circle **479** on inquiry card.

Toggle Switches. 2000 Series comprises four types in sp-st and dp-dt, with solder or screw terminals, 10 amp 250 vac and ½ hp 125-250 vac; UL approved.—Sargent Electric Corp., 630 Merrick Rd., Lynbrook, N. Y.
For more information circle **480** on inquiry card.

Tensile Test Clamps. Spruance semi-automatic tire cord clamps nullify human variations of different operators.—Scott Testers, Inc., 45 Blackstone St., Providence, R. I.
For more information circle **481** on inquiry card.

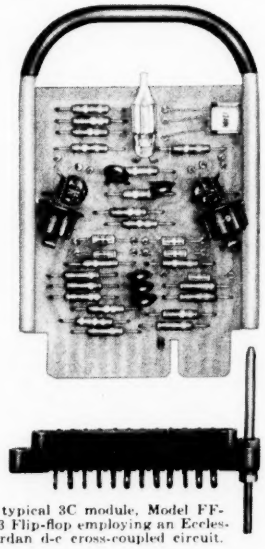
Metal Film Pot Resistors utilize specially-developed alloys evaporated in high vacuum and deposited onto a ceramic disc.—Servomechanisms, Inc., 12500 Aviation Blvd., Hawthorne, Calif.
For more information circle **482** on inquiry card.

Implement your digital system with

COMPUTER CONTROL

M PACs

M-PACs are fully compatible, transistorized, digital, plug-in, printed circuit modules. M-PACs provide the utmost in compactness — as many as 75 PACs may be mounted in a standard 8¾ inch rack panel space.



A typical 3C module, Model FF-103 Flip-flop employing an Eccles-Jordan d-c cross-coupled circuit.

The M-PAC family includes flip-flops, pulse amplifiers, gates, buffers, emitter-followers, variable frequency oscillators, crystal-controlled oscillators, inverter amplifiers, one-shot multivibrators, and others.

Typical applications of M-PACs . . .

- data handling
- control
- instrumentation
- computing systems

Write for illustrated 20-page Catalog M

3C

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COMPUTER CONTROL CO. Inc.
92 Broad St., Wellesley 57, Mass.
2251 Barry Ave., Los Angeles 64, Cal.

For more information circle **87** on inquiry card.

Ac Voltage Regulator. Tubeless all-purpose Model APR1010 can colve nearly all regulator problems found in lab or on production line, regulates average and peak voltages as well as rms; independent of input waveform.—Sorensen & Co., Inc., Richards Ave., S. Norwalk, Conn.

For more information circle **483** on inquiry card.

Frequency Changer. Low impedance portable Model FCR 100 with wide range of output frequency, excellent waveform, and low audio and radio noise, for equipment drawing up to 100 va. Sorenson & Co., Inc., Richards Ave., S. Norwalk, Conn.

For more information circle **484** on inquiry card.

Portable Potentiometer Pyrometer. Addition of four new interchangeable special scales enables Pyrotest to calibrate temperature instruments using any one of ten types of thermocouples.—Technique Associates, Inc., P. O. Box 91, Indianapolis 6, Ind.

For more information circle **485** on inquiry card.

Diode Tester. Model DT-257 combines lab precision with speed and convenience in production forward and reverse tests.—Teletronics Laboratory Inc., 54 Kinkel St., Westbury, L. I., N. Y.

For more information circle **486** on inquiry card.

Three High-power Frequency Converters, 250, 500 and 1000 v-a, are useful with mag amps, servo systems, etc., requiring 330 to 3,700 cps power.—Tel Instrument Electronics Corp., 728 Garden St., Carlstadt, N. J.

For more information circle **487** on inquiry card.

High Power Silicon Transistors with ratings to 80 watts feature low R_{sat} (typically 1.5 ohms), currents to 5 amp.—Transitron Electronic Corp., Wakefield, Mass.

For more information circle **488** on inquiry card.

Axial Lead Silicon Rectifiers have current ratings to 750 ma and voltage to 1000. Proposed military types and wide industrial variety.—Transitron Electronic Corp., Melrose 76, Mass.

For more information circle **489** on inquiry card.

Temperature Controller. Explosion-proof dual-switch remote-bulb Type E98A is for use in hazardous locations; features two separate switches. United Electric Controls Co., 79 School St., Watertown, Mass.

For more information circle **490** on inquiry card.

High-speed Scaler built to AEC specs. Model 762 comprises an input pulse height discriminator, a fast scale of 10, three slow-speed counter decades and a six-digit register.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

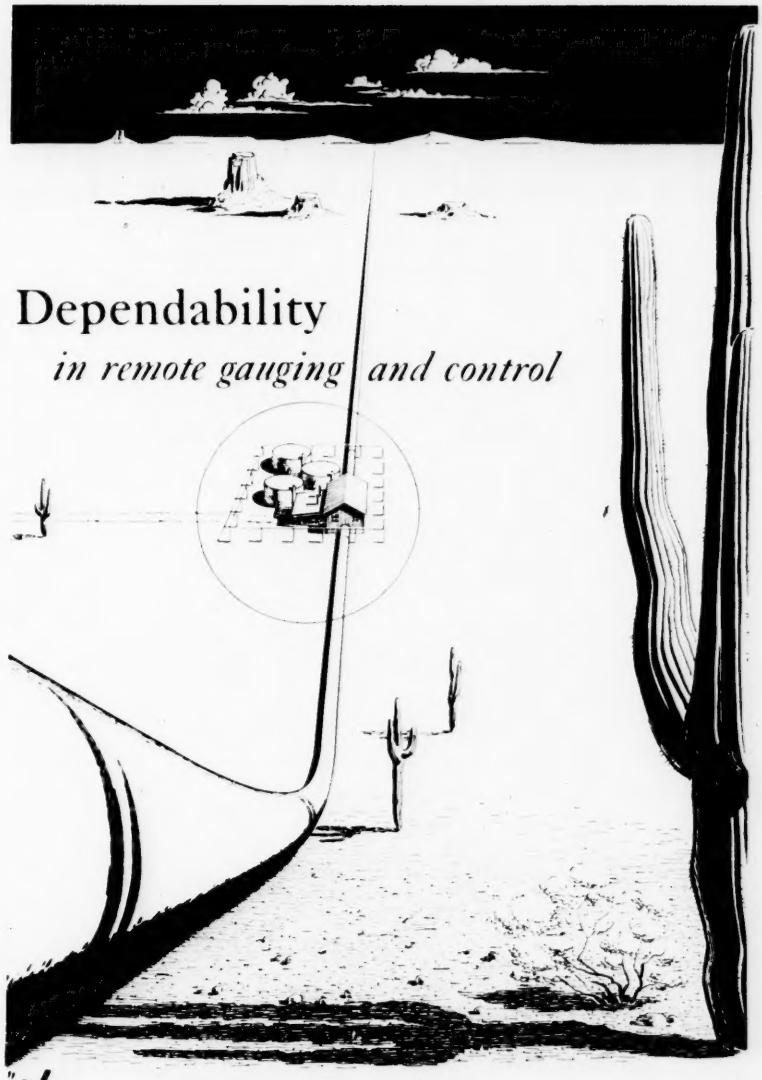
For more information circle **491** on inquiry card.

Miniature Capacitors. Radial Series offers extreme miniaturization, 300-v rating up to 100 mmf; thin design, $^{3}/_{64}$" to $^{7}/_{64}$".—Vitramon, Inc., Box 544, Bridgeport 1, Conn.

For more information circle **492** on inquiry card.

Tubular Resistor, low-cost Model 9858, with Varistor elements, is claimed to surpass performance of wire-wound units; physically interchangeable with MF type (JAN-R-29).—Weston Instruments, Newark 12, N. J.

For more information circle **493** on inquiry card.



"Varec" PULSE CODE TELEMETERING

ISOLATED LOCATIONS, such as this lonely pumping station, provide the acid test for remote control gauging and operating equipment. Prolonged exposure to the ravaging effects of sun, wind, sand and rapid temperature changes demands the absolute best in the design and manufacture of all equipment. There is never room for costly compromise.

"Varec"-equipped pipelines and refineries all over the world, operating automatically and efficiently, have proved the economic practicability of remote controlled gauging and operation. There are "Varec" models for automatic scanning and data printing, manual scanning, temperature reading and recording, automatic or manual actuation of valves, pumps and other field equipment, and automatically-controlled tank switching. "Varec" PULSE CODE always reads safe — if a pulse is lost or gained you get no reading, not an incorrect reading.

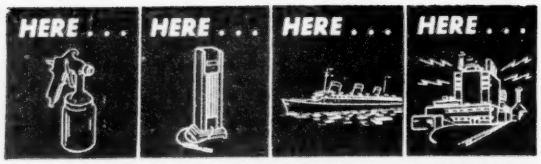
There are "Varec" models to perform many necessary functions involved with the operation of flow tanks, pumping stations, tank farms, and refineries automatically, economically, and dependably. For amazingly fast pay-out, automate with "Varec" — the pioneer and leader for over 30 years.

Write for Bulletin CP-3012 for full details on "Varec" PULSE CODE Telemetering.

"Varec"

The VAPOR RECOVERY SYSTEMS COMPANY
Compton, California, U.S.A.
Cable address: Varec Compton Calif (U.S.A.) All Codes
961-24

For more information circle **156** on inquiry card.



IN PLANTS THROUGHOUT THE WORLD
ENGINEERS SPECIFY

HANKISON Condensifilters

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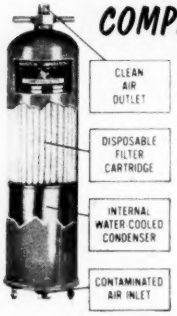
HERE IS YOUR ANSWER TO COMPRESSED AIR PROBLEMS



From steel companies to steamships . . . from paint spray equipment to power plants . . . wherever POSITIVE PROTECTION for pneumatic instruments and controls is required, Hankison Condensifilters are specified.

Condensifilters eliminate:

- Moisture, *entrained and vaporized*
- Oil, *entrained and vaporized*
- Dirt — Scale — Rust

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HC-12

Condensifilters are ASME coded.

HANKISON CORPORATION

College & Pike • Canonsburg, Pa.

For more information circle **157** on inquiry card.

new plants and mergers

Manning, Maxwell & Moore

MANNING, MAXWELL & MOORE's Industrial Controls Div. has moved from Stratford to a new plant in Danbury, Conn.

FOXBORO CO. has announced the opening of a new branch office in Denver.

MIDWESTERN INSTRUMENTS' MAGNECORD DIV. has been accepted for membership in the Electronic Parts and Equipment Manufacturers Incorporated Association.

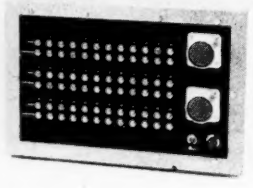
ENGELHARD INDUSTRIES announced consolidation of nine of its affiliated Companies under a unified Corporate management. They will function as fifteen divisions of the parent company.

COMMUNICATIONS ACCESSORIES CO., a subsidiary of COLLINS RADIO will take over the activities of the Dallas Transformer Dept. of the parent organization.

LEEDS & NORTHRUP automatic temperature control equipment for Hazel-Atlas Div., Continental Can Co., amounts to its largest order ever received from the glass industry . . . $450,000.

ASSEMBLY PRODUCTS has acquired Metronix, Inc. and thus adds a line of laboratory instrumentation and panel-mounted electronic voltmeters.

PACE



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NEW BRJ SERIES UTILIZES MAGNETIC AMPLIFIER CONTROL FOR EXTREME PRECISION — 1/5°F STABILITY

- REFERENCE TEMPERATURES from 25° F above ambient to 250° F — *Special models for reference temperatures below ambient.*
- CHANNEL CAPACITY up to 48 channels in standard 110 volt rack or cabinet models.
- MULTI-WIRE junctions for thermocouple choice in each channel.
- THERMOCOUPLE TABLES for 150° F reference available. Write for your copy.

PACE *engineering company*

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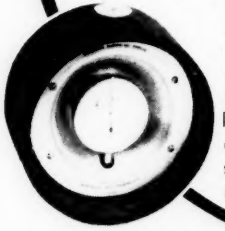
For more information circle **158** on inquiry card.

THE MOREHOUSE

RING DYNAMOMETER

. . . for the checking of **UNIVERSAL TESTING MACHINES, BRINELL HARDNESS TESTERS, HYDRAULIC AND MECHANICAL PRESSES and other force measurement equipment.**

The Morehouse Ring Dynamometer is an easy-to-use force measurement device with an accuracy of 0.1% at predetermined points on its scale. It can be used in place of a proving ring where sustained high accuracy is not required. Forces applied to the ring dynamometer are read in divisions on its precision dial indicator. The divisions are readily translated into pounds from a calibration report supplied with each instrument.



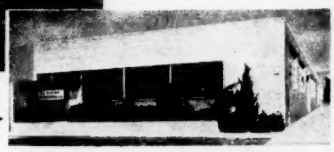
For more information, write for Bulletin 160.

MOREHOUSE MACHINE CO.

1742 Sixth Avenue • York, Pa.

For more information circle **159** on inquiry card.

◄ Bristol Company



Behlman Engineering Co. ►

THE BRISTOL COMPANY has added 27,000 sq ft to manufacturing and warehouse facilities at its plant in Waterbury.

BEHLMAN ENGINEERING CO. has moved into a new building in Burbank.

ECLIPSE FUEL ENGINEERING CO. has acquired all rights for Seico vane-type indicating flowmeters for gases and liquids which will be manufactured by its new Seico Instrument Div.

TEXAS INSTRUMENTS INC. and **IBM CORP.** have signed an agreement of cooperation on transistors for data processing machines.

INDUSTRIAL INSTRUMENTS, INC. has started a subsidiary company in Puerto Rico to meet the increasing demand for soil moisture test equipment.

CLEVITE ELECTRONIC COMPONENTS DIV. has concluded a licensing agreement with Ampex Corp. for the Clevite-Brush magnetic recording patents.

GREENBRIER INSTRUMENTS INC. is a new company formed in Ronceverte, W. Va., to manufacture analytical laboratory and process instruments, including an automatic chromatographic analyzer.

CAMBRIDGE GAS ANALYZERS

The Cambridge Recording Gas Analyzer continuously analyzes and records as many as six constituents of a gas. Eliminates intermittent, slow and expensive manual gas analysis. Accurate . . . Sensitive . . . Simple. No moving parts; utilizes thermal conductivity principle.

Makes possible substantial savings in the operation of kilns, production of inert gases, and in metallurgical, petroleum, and other chemical processes. Single- and Multi-point instruments are available for a wide variety of applications.

Send for literature mentioning application

CAMBRIDGE
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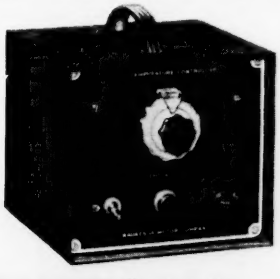
3554 Grand Central Terminal, New York 17
Pioneer Manufacturers of
PRECISION INSTRUMENTS

For more information circle **160** on inquiry card.

For CLOSE Temperature Control

TEMPERATURE SENSING PROBE



WAUKESHA
TEMPERATURE CONTROLLER

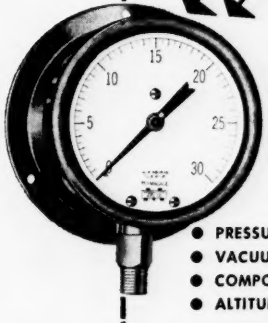
This simple, versatile instrument, developed for ASTM Engine Test Methods for Rating Motor Fuels, is equally well adapted to general laboratory or industrial temperature control applications. Range is approximately 80° F. to 400° F. with the standard sensing pickups. A small thermistor sensing probe and a saturable reactor provide continuously modulated proportional control of the current to the heating element, without moving contacts or relays. It features high sensitivity, close control, and easy adjustment of the control point by coarse and fine co-axial dials. It is housed in the portable cabinet shown, or may be panel mounted. Operates on 110 volts AC to control directly heaters up to 1000 watts, and can be used as a pilot controller for higher load capacity. Write for further information.

Fuel Research Division
WAUKESHA MOTOR COMPANY
WAUKESHA, WISCONSIN

For more information circle **161** on inquiry card.

MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS



Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

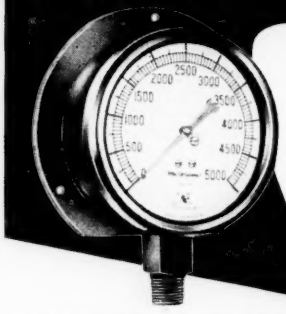
- PRESSURE
- VACUUM
- COMPOUND
- ALTITUDE
- COMBINATION
- DIAPHRAGM
- HYDRAULIC
- AND SPECIAL PURPOSE GAUGES
- DIAL THERMOMETERS (Vapor Tension or Bi-Metal)

WRITE TODAY FOR COMPLETE INFORMATION

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **162** on inquiry card.

MARSH *Mastergauge*



The gauge that has everything!

- **LEAK-PROOF ONE-PIECE CONSTRUCTION** . . . bourdon tube fused to socket and tip by exclusive "Conoweld" process.
- **STURDY "MARSHALLOY" CASE** . . . formed of boiler-plate-thickness steel, copper clad inside and outside to give it the corrosion resistance of solid copper. It's one third lighter, but four times stronger than cast iron.
- **PRECISION "MASTERGAUGE" MOVEMENT** . . . with such exclusive features as the coined sector gear.
- **AVAILABLE WITH STAINLESS TUBE AND SOCKET** . . . choice of stainless steels and alloys for all corrosive conditions.
- **WITH "RECALIBRATOR"** . . . quickest and best way to keep a gauge accurate.

These features are combined only in "Mastergauge", standard bearer for the broad line of Marsh Gauges . . . each the best of its kind. Ask for data.

MARSH "THE STANDARD OF ACCURACY"

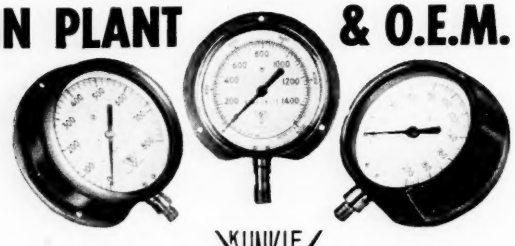
MARSH INSTRUMENT CO., *Sales Affiliate of Jas. P. Marsh Corp.*, Dept. 42, Skokie, Ill.
Marsh Instrument and Valve Co. (Canada) Ltd. 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas.

For more information circle **163** on inquiry card.

GAUGES NOW COMPLETELY CATALOGED WITH ENGINEERING DATA

FOR PROCESS & POWER INSTRUMENTATION

IN PLANT & O.E.M.



KUNKLE GAUGES

Complete, broad range line makes gauge application-specification easy with assured results backed by 50 years of gauge manufacturing experience.

Ranges from 15 p.s.i., or 30" of vacuum, to 20,000 p.s.i.

Bourdon tubes of bronze, drawn or bored s/s, and other alloys

YOUR COPY SHOWING NEW GAUGES AND SPEC. DATA NOW AVAILABLE WRITE:

By the makers of dependable Kunkle Valves
KUNKLE VALVE CO. · FT. WAYNE, IND.

For more information circle **164** on inquiry card.

people in the news

H. J. Andrews

L. L. Wilkes, Jr.

R. W. Olmstead

FENWAL ELECTRONICS has appointed *H. J. Andrews* sales manager.

CAMBRIDGE THERMIONIC has appointed *Lowell L. Wilkes, Jr.* sales manager.

ELECTRONIC ASSOCIATES, INC. has appointed *Richard W. Olmstead* advertising manager.

RAMO-WOOLDRIDGE CORP. has appointed *Irwin A. Binder* as vice president for manufacturing.

RADIO FREQUENCY LABS recently elected *Henry H. Emker* vice president in charge of marketing, Communications Products Div.

POWERS REGULATOR CO. has announced changes in headquarters sales staff with the appointment of *Horace W. Fea* as advertising director, *Earl R. Bowman* as advertising manager, *Carl A. Gustafson, James J. Atkinson,* and *Robert W. Clark* as product managers for different divisions.

OPTICS

A. D. JONES OPTICAL WORKS

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CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368 — 3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

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ALUMINA
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ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITINATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COPPER
*CORNING 707
*CORNING 7052
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GERMANIUM
INDIUM ANTIMONITE
INDOX
MELAMINE FIBER GLASS
MICA, SYNTHETIC
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITINATE
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

*Carried in stock
**Purchased for orders

For more information circle **165** on inquiry card.

J. H. Dalton

M. Baldwin

H. W. Ziebolz

SERVO CORP. of America has appointed *J. H. Dalton* as assistant to the president.

BECKMAN & WHITLEY, INC. has appointed *Myron Baldwin*, former product manager of the camera dept., as sales manager of the Instrument Division.

GENERAL PRECISION EQUIPMENT CORP. has appointed *Herbert W. Ziebolz* coordinator of industrial systems and assistant to the vice president of engineering.

NATIONAL CO. INC. has appointed *Curtis Kelly* as sales manager consumer products.

NRC EQUIPMENT CORP. has named *James H. Moore* as general manager and *Harry D. Stone* as sales manager of this wholly owned subsidiary of National Research Corp.

Curtis Kelly

H. D. Stone

J. H. Moore

KNOPP
Phase Shifter

Type Q

Every Degree between 90° leading to 90° lagging

You can have any leading or lagging phase angle by manually controlling the position of the rotor of the KNOPP PHASE SHIFTER.

Smoothly and continuously variable, it is quick and easy to use for testing electronic equipment and their control circuits, watt-hour meters, rotating standards watt-meters, power-factor indicators, induction relays, and instrument transformers.

Has two direct-reading scales. One is calibrated in degrees for the electrical angle of displacement; the other, in corresponding power-factor values.

Compensates for any phase displacement between current and potential of test setup that may be introduced by other portions of the circuit. Thus it gives true-power-factor-readings under all conditions.

The KNOPP PHASE SHIFTER offers superior performance, stability and high accuracy. Rated at 250 or 500 volt-amperes. Input: 120/240 volts, 3-phase, delta. Output: 120 or 240 volts, 3-phase, delta. Can be supplied in other ratings.

Write now for full details.

KNOPP INC.

Dept. A-8, 1307 66th St., Oakland 8, Cal.

For more information circle **167** on inquiry card.

permanent graduated markings now available on

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THERMOMETERS

pigment provides everlasting legibility

PRINCO laboratory thermometers are your assurance of everlasting legibility, easier readability and greater accuracy—for their STAZON markings will withstand the action of acids, caustics, and solvents, or any liquid which will not harm glass.

Look for the name STAZON enclosed in the infinity mark. It is your guarantee that the graduations and figures, which have actually become part of the glass itself, will remain legible for the life of the thermometer.

Write, wire or call for further information on this latest result of PRINCO research and development.

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Petrometer

SERIES 1400

LIQUID DEPTH GAUGES

ACCURATE and EASY TO INSTALL

Available in 4 Models, Petrometer Series 1400 Tank Gauges operate on the sound principle of hydrostatic pressure. No moving parts, no expensive electrical or electronic equipment. Large vertical scale gives accurate, easy-to-see reading. And construction features make installation easy.

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CORPORATION

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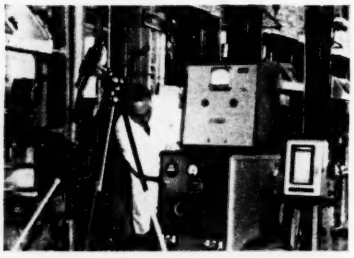
Critical Problem in Titanium Forging is Solved—



with INFRARED

Republic Aircraft hit problems — heat problems — in forming titanium sections. The metal had to be held within a *close* temperature range even during the actual working under the hammer.

Resistance heating was the natural way for bringing the blanks up to temperature . . . but the stopper was how to maintain adequate control of temperature while handling the metal in the press. Then Republic turned to Servo Corporation's infrared pyrometers, and found they had the answer.

Remote control of the temperature, *without* any connection or contact with the metal or machine, is maintained in this application by the SERVOTHERM® Infrared Pyrometer. The SERVOTHERM provides highly accurate and instantaneous control of the temperature, the process, *or both*, in almost any kind of operation, by measuring the infrared radiation emitted by the material or equipment involved.

Almost any control problem, where heat is a related variable — whether of a basic *or* an incidental nature — is easily solved with a SERVOTHERM Pyrometer System. The effectiveness of infrared control applies to materials or objects that are moving or stationary, whether liquid, solid, or powdered — granular in form, in the temperature range from 40° to 2800°F.

The leading firm in infrared, Servo Corporation of America produces the world's widest range of infrared equipment — systems and components, assemblies and accessories. The modular principle of building custom IR systems from "standard units" is also a Servo Corporation development.

For data on Servo Corporation's infrared equipment, from single items to complete IR systems for almost any type of control function — in laboratory or production line use, write for our new technical bulletin on Infrared Pyrometers, TDS IRPS-R1, or consult our application engineering staff. Call or write:

SERVO CORPORATION of AMERICA

20-18 Jericho Turnpike, New Hyde Park, L.I., N.Y.

For more information circle **169** on inquiry card.

new literature

AUTOMATION

COMBUSTION CONTROL. 12-page Publication 57-1088-239, on new preassembled packaged combustion control system, details the ten separate systems available; contains schematics, program control chart, piping and wiring details, etc.—The Hays Corp., Michigan City 39, Ind.

Circle **501** on inquiry card.

PUNCH PRESS CONTROLLER, with double stop, to prevent shut-down time on high-speed automatic presses is described in new 2-page Bulletin AC 5.—Tipptronic, Inc., 68 Olive St., Chagrin Falls, Ohio.

Circle **502** on inquiry card.

REMOTE SUPERVISORY CONTROL. 8-page brochure describes low-cost Centralized Operations Control capable of endless combinations and adaptations.—Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.

Circle **503** on inquiry card.

MOTORS, SERVOS

SERVOMOTOR. 4-page Data Sheet 1258 introduces 115-v 400-cps Size 15 Servomotor featuring acceleration at stall of 100,000 rad/sec²; operates at 200°C.—Beckman Helipot Corp., Newport Beach, Calif.

Circle **504** on inquiry card.

MINIATURE HIGH-TORQUE MOTOR which operates under temperature extremes of -100°F to 500°F at 60 or 400 cps ac or pulsating dc is described in 2-page Data Sheet AM1.—The Viking Tool and Machine Corp., 20 Main St., Belleville 9, N. J.

Circle **505** on inquiry card.

SERVOMECHANISMS. 4-page bulletin describes light-weight dc "package" comprising servo amplifier, dc-to-dc converter, motor, and accessories.—Advanced Research Associates, Inc., 4128-B Howard Ave., Kensington, Md.

Circle **506** on inquiry card.

SYNCHROS, etc. Broad Sheet (equivalent of 6 pages) describes synchros, servomotors, resolvers, motor tachometers and tachometer generators in production.—Muirhead Instruments Inc., 677 Fifth Ave., New York 22, N. Y.

Circle **507** on inquiry card.

VALVES

CONTROL VALVES. 4-page Specification S-810-16 describes Honeywell Series 800 3-way control valves; single and double-seated designs for mixing or diverting service.—Minneapolis-Honeywell Regulator Co., Valve Div., Fort Washington, Penna.

Circle **508** on inquiry card.

CONTROL VALVES. 8-page Bulletin W8-A describes new Cushioned Flow-trol Valve featuring air and water cushioning to prevent hammer or shock; operated by fluid in line or by independent power source.—Golden Anderson Valve Specialty Co., 1232 Ridge Ave., Pittsburgh 33, Pa.

Circle **509** on inquiry card.

AUTOMATIC VALVES. 4-page Bulletin 7F describes maker's more popular pressure reducing and regulating valves, back pressure valves and diaphragm operated control valves.—Cash-Acme, P. O. Box 191, Decatur, Ill.

Circle **510** on inquiry card.

CYLINDER ACTUATORS. 12-page Bulletin B-50-3 describes complete line of Series 50 Cylinder Conomotor actuators for proportional control of different types of final elements.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

Circle **511** on inquiry card.

TEMPERATURE

PILOT-OPERATED TEMPERATURE REGULATORS are described in 6-page Bulletin 1012 on two new series of steam regulating valves with pilots for both fast and slow heating exchangers.—Spence Engineering Co., Inc., Walden, N. Y.

Circle **512** on inquiry card.

TEMPERATURE INDICATOR CONTROLLER. 2-page Bulletin 320-I gives dimensions, specifications, wiring diagram and installation instructions for Model MFS Indicating Temperature Control.—The Partlow Corp., New Harford (Utica), N. Y.

Circle **513** on inquiry card.

THERMOMETRIC INSTRUMENTS. 60-page Catalog C60-2 describes complete line of Brown rectangular-case filled-system temperature indicators, recorders, transmitters, and electric or pneumatic control instruments; covers vapor, gas and mercury types; also separable wells and other accessories.—Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Phila. 44, Pa.

Circle **514** on inquiry card.

THERMOSTATS. 2-page Data Sheet F-1625-8 describes mercury-system immersion thermostat, bimetal-system and thermostat; also manual-reset, two-wire strap-on and summer-winter changeover thermostats.—Barber-Colman Co., 1300 Rock St., Rockford, Ill.

Circle **515** on inquiry card.

THERMAL-CONDUCTIVITY CELLS. 6-page bulletin describes nine "on-stream" cells; also indicating and recording instruments.—Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.

Circle **516** on inquiry card.

THERMOCOUPLES. 2-page Bulletin 3.8 describes "green tip" metal-sheath ceramic-insulated assemblies for temperatures to 2500°F and pressures to 50,000 psi, which can be bent or coiled without loss of insulation.—Aero Research Instrument Co., 315 N. Aberdeen St., Chicago 7, Ill.

Circle **517** on inquiry card.

THERMOCOUPLE EXTENSION WIRES. 8-page revised catalog No. 32 covers

many types of thermocouple and extension wires; contains useful data charts.—Thermo Electric Co., Inc., 109 Fifth St., Rochelle Park P. O., Saddle Brook, N. J.

Circle **518** on inquiry card.

SURFACE PYROMETER. 8-page brochure describes self-contained Model 1331 with bimetal compensator for room temperature variations; featuring complete accessory interchangeability.—Pyrometer Service Co., 348 River Rd., N. Arlington, N. J.

Circle **519** on inquiry card.

PYROMETERS. 8-page Bulletin GEA-6650 describes complete pyrometer line with emphasis on printed circuits, lead length compensation, and flexibility.—General Electric Co., Schenectady 5, N. Y.

Circle **520** on inquiry card.

FLOW, LEVEL

FLOWMETER SELECTION. 4-page Bulletin 110 utilizes a novel and convenient means for aiding prospective users: a die-cut disc, eyeletted on inside cover, indicates pressure and temperature limitations of Brooks rotameters as well as their flow capacity ranges; indicated meter in turn is tied into brief description given on an opposite page.—Brooks Rotameter Co., Lansdale, Penna.

Circle **521** on inquiry card.

LIQUID LEVEL GAGES. 2-page Bulletin 306 describes magnetic gage, free from glass, gaskets and threads.—8-page brochure describes Truscale remote-reading gage with new convex scale.—2-page bulletin describes Inclined Truscale for high or low mounting.—Jerguson Gage & Valve Co., 100 Adams St., Burlington, Mass.

Circle **522** on inquiry card.

PRESSURE, VACUUM, WEIGHT

PNEUMATIC INSTRUMENTS. 16-page Catalog 510 describes complete line of indicating pressure or temperature controllers, transmitters for pressure or temperature indication; and receiving instruments.—United States Gauge, Div. of American Machine and Metals, Inc., Sellersville, Penna.

Circle **523** on inquiry card.

WATER MANOMETER. 2-page bulletin describes high-precision Minimeter reading to 0.002 mm water (0.00008") for calibrating low-pressure and vacuum gages.—Epic, Inc., 154 Nassau St., New York 38, N. Y.

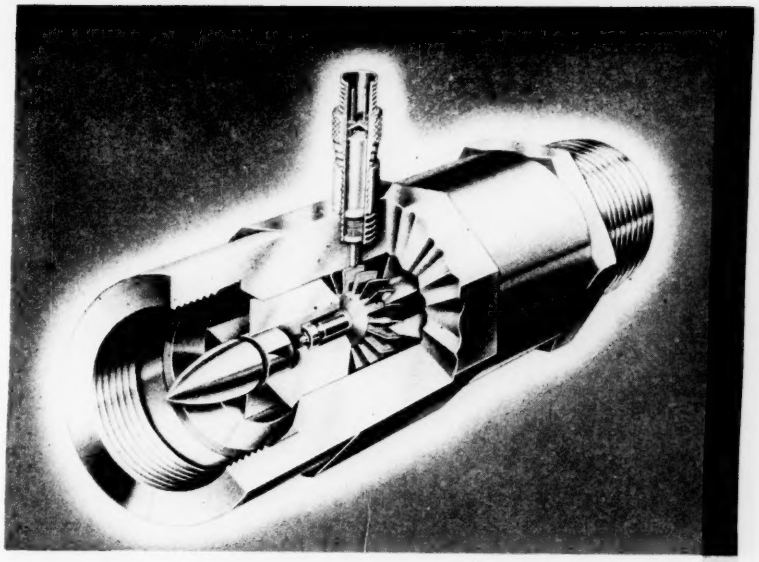
Circle **524** on inquiry card.

INDUSTRIAL INSTRUMENTATION. Catalog 76-G is a binder containing a set of catalogs (about 80 pages total) on pressure and vacuum gages, thermometers, throttling valves, needle valves, fittings, etc.—Marsh Instruments, 3501 Howard St., Skokie, Ill.

Circle **525** on inquiry card.

PRESSURE TRANSDUCER, COMPARATOR. Two new 2-page catalog sheets are available. No. 59-100 explains operation of Pneumatic Transducer, Model 59WL100A; No. 32CA110 describes new Pressure Comparator.—Fischer & Porter Co., 495 Jacksonville Rd., Hatboro, Penna.

Circle **526** on inquiry card.



★ Meticulously calibrated to insure 1/2% accuracy
★ Easily disassembled for cleaning
★ High frequency output — 120 to 1200 cps
★ High transient frequency response
★ Unharmed by reverse flow

new cox turbine flowmeter

For over 46 years the name "Cox Instruments" has been synonymous with *precision* flow measurement. Such outstanding equipment as Cox Variable-Area Flowmeters and Cox Calibrating Stands have helped make it possible for industry to establish realistic standards for accuracy and reliability in flow measurement.

And now . . . the Cox *Turbine* Flowmeter joins this list of truly precision products. Developed to meet the exacting needs of modern instrumentation systems, it has received the acclaim of initial users throughout industry.

We welcome the opportunity to tell you more about the complete line of Cox Turbine Flowmeters. Write to *Cox Instruments Division, George L. Nankervis Company, 15200 Fullerton Avenue, Detroit 27, Michigan.*

COX INSTRUMENTS

A new technical bulletin describes the complete line of cox turbine flowmeters. Ask for bulletin no. 1300a.

Precision Instruments Since 1912

GLN-1259

For more information circle **170** on inquiry card.

NEW LITERATURE

PNEUMATIC RELAYS. 2-page Bulletin 58-2 describes ratio-type and multiplying-type relays for achieving modern null-balance automatic control systems; and saving costs by interchangeability and simplified training requirements.—Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

Circle **527** on inquiry card.

PRESSURE PICKUPS. 4-page bulletin on engine-pressure pickups for temperature-compensated dynamic pressure measurement; seven 2-page Technical Data Sheets on special and general-purpose pressure pickups.—Norwood Controls, 934 Washington St., Norwood, Mass.

Circle **528** on inquiry card.

PLATFORM SCALES. 8-page catalog insert covers standard dormant scales in a wide variety of platform sizes and capacities, both with Type A Column attachment and Unit Weight Cabinet attachment.—Detecto Scales, Inc., 540 Park Ave., Brooklyn 5, N. Y.

Circle **529** on inquiry card.

ENGINE INDICATOR for pressure, and ignition and vibration analysis. 4-page Bulletin EA-114 describes SLM Engine Indicator designed to measure all internal-combustion engine pressures, ignition and vibration.—Kistler Instrument Corp., 15 Webster St., N. Tonawanda, N. Y.

Circle **530** on inquiry card.

VACUUM EQUIPMENT. 16-page product summary and price list covers complete line of standard and custom high-vacuum components, equipment and system: mechanical and diffusion pumps, gages, valves and accessories.—NRC Equipment Corp., 160 Charlemont St., Newton 61, Mass.

Circle **531** on inquiry card.

TIME, COUNT

ELECTRONIC COUNTING. 4-page Catalog 2-57 describes preset and dual-preset counters; time-interval, frequency and combination TI&F meters; frequency meters with or without printout.—Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Circle **532** on inquiry card.

ELECTRONIC COUNTERS. Three 2-page bulletins describe Model SD-1 intermediate-decade counter, Model P-6 preset counter for batches from 1 to 1,000,000, and Model LF-1 lineal footage counter.—Post Machinery Co., Electronic Products Div., Beverly, Mass.

Circle **533** on inquiry card.

COUNTERS. 18-page "Extract of Catalogue 57" describes mechanical and electromagnetic counters; many sizes and types including printing counters.—Presin Co., 12128 W. Pico Blvd., Los Angeles 64, Calif.

Circle **534** on inquiry card.

TIMERS, SWITCHES and other automatic electrical control equipment are illustrated and described in new 64-page Catalog 18.—Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill.

Circle **535** on inquiry card.

LABORATORY, ANALYTICAL

MICROPHOTOMETER. 4-page Data Sheet E-9004(1) describes Knorr-Albers Microphotometer and its use for measuring photographic densities of exposed spectrographic and x-ray plates.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **536** on inquiry card.

COMBUSTIBLE GAS ANALYZER. 8-page bulletin describes flexible new Model F for centralized process control and industrial safety.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

Circle **537** on inquiry card.

COLOR AND TURBIDITY TITRATIONS. 6-page Bulletin #355 describes new combination of Photoelectric Colorimeter Model 401 with recently developed Titration Adapter, said to be the first commercially-available equipment for rendering color and turbidity titrations independent of individual judgement.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Circle **538** on inquiry card.

PARTICLE SIZE ANALYZER. 4-page Bulletin 0708-1 describes a new general-purpose instrument for size distribution of small particles.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

Circle **539** on inquiry card.

"GEARED-PAIR" ESCO type HT. Rotary Switch Assembly

Doubles the number of circuits controlled by a single knob

- Sections — 24 sections per assembly.
- Positions — 16 positions, one being OFF.
- Poles — one per section, two sections/pole for 16 ON positions.
- Electrical Rating — 5 amperes 125 volts a-c, 0.80 power factor.
- Contacts — break-before-make, standard.
- Action — detent action, 22½° indexing.
- Movement — unlimited rotation in either direction.

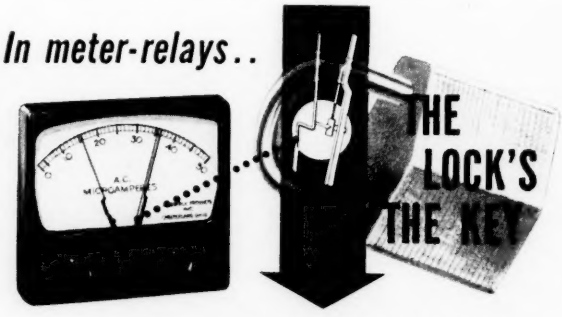
Special assemblies to meet your particular requirements will be supplied.

Write today for further information on the ESCO "Geared-pair" Type HT rotary multipole switches.

ESCO of WEYMOUTH
ELECTRO SWITCH CORPORATION
Weymouth 88 Massachusetts

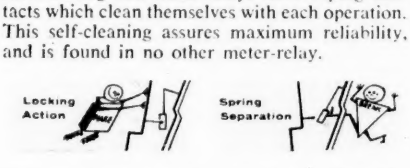
For more information circle **171** on inquiry card.

In meter-relays..



–to Contact RELIABILITY!

API locking coil meter-relays have wiping contacts which clean themselves with each operation. This self-cleaning assures maximum reliability, and is found in no other meter-relay.



When contacts touch, the locking coil grabs and holds them. They are sharply separated by a spring which is loaded during locking. This positive make and break gives 10 to 20 million trouble-free operations.

Ask for Catalog 4-D

Assembly Products Inc.
ap
Chesterland 10, Ohio
Booth 3815, IRE Show, Coliseum, N. Y. C., March 24-27

For more information circle **172** on inquiry card.

ULTRAVIOLET UNIT. 4-page Bulletin 60 describes Model 60 for continuously analyzing components in flowing gas or liquid samples which absorb ultraviolet or visible radiation, or which can be converted or related to a suitable absorbing substance.—Analytic Systems Co., 980 N. Fair Oaks Ave., Pasadena, Calif.

Circle **540** on inquiry card.

ELECTROPHORESIS. 8-page Catalog SBR-2 describes "Model R" paper electrophoresis system.—Beckman Instruments, Inc., Spinco Div., Stanford Industrial Park, Palo Alto, Calif.

Circle **541** on inquiry card.

X-RAY ANALYSIS. 16-page booklet titled "Questions and Answers on X-ray Diffraction, Diffractometry and Spectrography" explains specimen preparation and describes fields of application; discusses selection of analyzing crystals and calibration of spectrograph for quantitative work on elements.—Instruments Div., Phillips Electronics, Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

Circle **542** on inquiry card.

LABORATORY APPARATUS. "Cenco News Chats" No. 85 contains descriptions of Cenco-Indiana Smoke Point Lamp, Vapor Phase Analyzer, Transistorized Titrator, Electronic Electrometer, and many accessories for laboratory use.—Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

Circle **543** on inquiry card.

ACID RESISTANT LAB WARE. 16-page Catalog E956 covers 64 polyethylene and Nylon products unaffected by concentrated acids, oxidizing agents, hydroxides and polar liquids.—General Scientific Equipment Co., 7516 Limekiln Pike, Phila. 50, Pa.

Circle **544** on inquiry card.

HUMIDITY

HUMIDITY MEASUREMENT. 4-page Bulletin EH-4001 describes new Electrolytic Hygrometer available in portable, panel-mounted, and explosion-proof models; detects one part water in one million parts of air.—Beckman/Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle **545** on inquiry card.

HUMIDITY MEASUREMENT. Three 2-page bulletins describe motorized psychrometers (one is battery-powered) and other instruments.—E. Vernon Hill & Co., P. O. Box 189, Lake Geneva, Wis.

Circle **546** on inquiry card.

OPTICAL

INFRARED-TRANSMITTING GLASS. 8-page Bulletin TDS-4 describes nontoxic, non-corrosive homogeneous Servofrax arsenic trisulfide glass; lists over 50 different optical flats, about 25 single-element lenses and a number of achromat lenses.—Servo Corp. of America, 2020 Jericho Turnpike, New Hyde Park, N. Y.

Circle **547** on inquiry card.

OPTICAL TOOLING. 4-page brochure describes uses of new Opto Tooling Auto-Collimator reading directly to 1 second of arc and 5 microinches.—George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.

Circle **548** on inquiry card.

TRANSITS. 4-page Bulletin OP-100 describes two new transits featuring built-in optical plummets.—W. & L. E. Gurley, 535 Fulton St., Troy, N. Y.

Circle **549** on inquiry card.

ELECTRONIC DENSITOMETER. 8-page bulletin contains technical detail and step-by-step photos on new Macbeth-Ansco Model 12-A featuring 0-4.0 scale and accuracy of 0.02 density unit.—Dept. P. 10, Macbeth Corp., Newburgh, N. Y.

Circle **550** on inquiry card.

OPTICAL PARTS. 16-page Catalog L-117 covers full line of unmounted optical parts, including lenses, prisms and reflectors; contains detailed tables.—Bausch & Lomb Optical Co., Rochester 2, N. Y.

Circle **551** on inquiry card.

AUDIO-VISUAL PRESENTATION. 4-page bulletin introduces "Auvimatic" which projects series of slides on 18" x 26" eye-level screen and simultaneously speaks messages by hi-fi amplifier.—Polytronics Inc., 7326 Westmore Rd., Rockville, Md.

Circle **552** on inquiry card.

MICROSCOPES. 8-page catalog begins with an explanation of phase microscopy; describes new Phasestar and its accessories.—American Optical Co., Instrument Div., Buffalo 15, N. Y.

Circle **553** on inquiry card.

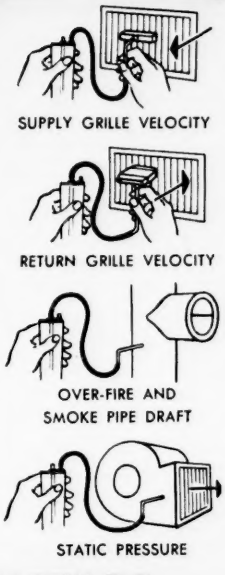
DATA HANDLING

TAPE RECORDER/REPRODUCER system is described in 2-page Bulletin

NEW NO. 460 AIR METER

BY Dwyer

NOW AN ALL-PURPOSE LOW-COST INSTRUMENT FOR STATIC PRESSURE AND AIR VELOCITY MEASUREMENTS



High *and* low ranges give direct velocity readings from 260 to 4000 fpm., static pressure readings from .005 to 1.0 inches of water. A complete instrument kit with every accessory needed for adjusting and balancing air conditioning, heating and ventilating equipment. The entire kit will fit in your shirt pocket.

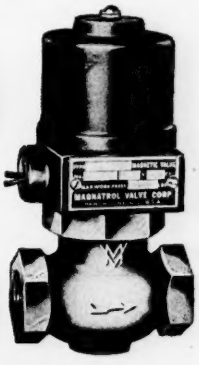
WRITE FOR BULLETIN B-9

F. W. DWYER MFG. CO.

P. O. BOX 373-S MICHIGAN CITY, INDIANA

For more information circle **173** on inquiry card.

Eliminate Costly Flow Failures



Magnatrol SOLENOID VALVES

Quick Operating *Non Sticking* *Tight Seating*

These three design advantages are your assurance against costly flow failures. Attain dependable, accurate, automatic or remote control of liquids or gases with **Magnatrol Valves**. Installed quickly and easily in connection with . . . flow-meters, thermostats, float and time switches. **Every Magnatrol Valve** is delivered to you—factory **tested**—guaranteed free from defects in material and workmanship.

Available in normally closed or normally open models. Pressure ranges from zero up to 300 PSI. Voltages to 575.

Catalog containing complete specifications mailed upon request.

Magnatrol VALVE Corp. HAWTHORNE 14 NEW JERSEY

For more information circle **174** on inquiry card.

NEW LITERATURE

CEC 1576-X16.—Consolidated Electrodynamics, 300 North Sierra Madre Villa, Pasadena, Calif..

Circle **554** on inquiry card.

DIGITAL COMPUTER. 16-page bulletin on G-15 general-purpose digital computer featuring simplified programming whereby engineers can be taught coding techniques within 2 to 4 hours.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles, Calif.

Circle **555** on inquiry card.

HIGH-SPEED SEAMING SWITCH with ten years' life when scanning at 10 points per second is thoroughly described in 8-page brochure.—Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.

Circle **556** on inquiry card.

DIGITAL TAPE SYSTEM. 16-page brochure describes new magnetic-tape input/out system for digital computers and related equipment, featuring fail-free operation, and transfer rates up to 90,000 characters per second.—Ampex Corp., Instrumentation Div., 934 Charter St., Redwood City, Calif.

Circle **557** on inquiry card.

MAGNETIC SHIFT REGISTER. resin dipped, is described in Engineering Data Sheet 9022A just released to the computer industry at large on Type 92Z.—Sprague Electric Co., North Adams, Mass.

Circle **558** on inquiry card.

COMPUTER USES. 4-page article, "Can Consulting Engineers Compete Without Electronic Computers," is a case study.—Royal McBee Corp., Port Chester, N. Y.

Circle **559** on inquiry card.

ENCODER AND DECODER. Two 2-page bulletins describe new high-speed high-accuracy drift-free low-noise converters.—Andromeda, Inc., 3742 Howard Ave., Kensington, Md.

Circle **560** on inquiry card.

DIGITAL METHODS. 4-page brochure, titled "Digitometry, a Concept of Digital Control and Indication," describes five new components for use as digital actuators and feedback devices in servo and instrumentation systems.—Digitran Co., 45 W. Union St., Pasadena, Calif.

Circle **561** on inquiry card.

COMPUTER COMPONENTS. 16-page Catalog T gives descriptions and technical specs on Transistorized T-Pac 1-Mc Digital Modules; 24-page Catalog M-1 covers extensive line of transistorized modules for digital systems.—Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass.

Circle **562** on inquiry card.

RECORDERS

STRIP-CHART RECORDERS. 16-page Catalog 657 covers direct-writing instruments for electrical variables and for pressure, vacuum, speed, etc. —The Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis 6, Ind.

Circle **563** on inquiry card.

RECORDERS for impact, acceleration, and gravity are described and specified in new 4-page bulletin.—The Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland 15, Ohio.

Circle **564** on inquiry card.

GAGING, TESTING

GONIOMETRY. 4-page reprint of article, "Testing Circular Division with Precision Polygons," describes use of a precision reflecting polygon with a Microptic Autocollimator to check circular spacing accuracy of rotary tables, dividing heads, etc.—Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

Circle **565** on inquiry card.

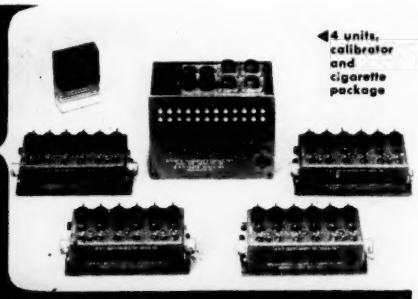
SCREW-THREAD GAGING. Two mineographed bulletins: No. 400, "Does the Three-Wire System Measure True Pitch Diameter;" No. 401, "The Effectiveness of Various Contacting Elements Used for Gaging and Measuring Pitch Diameter," are timely, in light of 1957 Supplement of H-28 Screw-Thread Standards.—The Johnson Gage Co., 534 Cottage Grove Rd., Bloomfield, Conn.

Circle **566** on inquiry card.

AIR GAGE MEMBERS. 20-page manual-type brochure describes air gage members for all types of circuits, attempts to orient the reader in the general principles of basic air gage instrument design and engineering.—Freeland Gauge Co., 9940 Freeland Ave., Detroit 27, Mich.

Circle **567** on inquiry card.

USE 6 12 18 24



CHANNELS AS YOU NEED THEM

with NEW B & F Sub-Miniature, Unitized Automatic-Calibrating Bridge-Balance System for STRAIN GAGES, PRESSURE PICKUPS, ACCELEROMETERS, etc.

- Each Model 6-104 (20 cu. in.) is a complete 6 channel unit
- Individual channel control features of larger models
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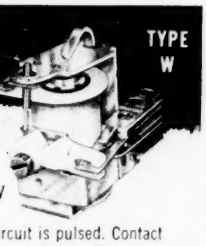

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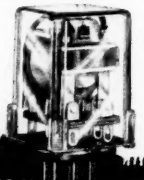

TYPE M LIGHT DUTY GENERAL PURPOSE RELAY

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LEAK DETECTION. 12-page Form IB is the second in a series of Technical Information bulletins regarding use of nitrous oxide for leak detection systems; contains schematics of testing systems, photographs, sketches, tables of physical constants, equivalents, and delivery units.—Ohio Chemical & Surgical Equipment Co., 1400 E. Washington Ave., Madison 10, Wisc.

Circle **568** on inquiry card.

TAPER GAGE. 2-page bulletin describes unique "Taper-Mike" which measures taper to 0.0001" without removing work from machine.—Taper Micrometer Corp., 100 Grove St., Worcester, Mass.

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PRECISION ANGULAR MEASUREMENTS. 8-page brochure describes new "Unisec" Coincidence Reading System which reads a 5" circle to 1 second of arc directly.—W. & L. E. Gurley, 514 Fulton St., Troy, N. Y.

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AIR- GAGING. 8-page Bulletin 8007 describes pneumatic comparator gages for inspection and quality-control fields.—Moore Products Co., H & Lycoming Sts., Phila. 24, Pa.

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LINEARITY TESTER. 4-page bulletin describes new Model 10 Spectrol which will test all types of potentiometer linearity: independent, zero based, terminal based and absolute. Special masters made to customer's specs furnish continuous readings on non-linear functions.—Spectrol Electronics Div. of Carrier Corp., 1704 S. Del Mar Ave., San Gabriel, Calif.

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PHYSICAL TESTING. 20-page (plus inserts) Bulletin 1400 on Testing Instruments, describes Stiffness Tester; Smoothness—Porosity—Softness Tester; High Pressure Porosity and Smoothness Tester; etc.—W. & L. E. Gurley, 514 Fulton St., Troy, N. Y.

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BALANCING MACHINES. 10-page Bulletin 56 describes new line of Rava Electrodynamic Balancing Machines featuring easy operation and setup both for production runs and small quantities.—Tinius Olsen Testing Machine Co., 7708 Easton Rd., Willow Grove, Penna.

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ENVIRONMENTAL TESTING. Binder contains a series of 2-page bulletins describing test chambers, and four sheets of useful tables on humidity, altitude, etc.—Environmental Equipment Corp., 369 Linden St., Brooklyn 27, N. Y.

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LEAK DETECTION. 8-page brochure describes Radiflo non-destructive system which can test after all sealing operations are complete, and can test thousands of components daily.—American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.

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PIPE, FITTINGS

FITTINGS FOR HYDRAULIC HOSE. 8-page Catalog 4440 describes reusable no-skive type Hoze-lok fittings for use with rubber-covered wire braided hydraulic hose.—Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

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SMALL-DIAMETER GLASS PIPE and fittings, sizes ¼" to ¾", are described in 4-page Catalog SG-11.—Sentinel Glass Co., Hatboro, Penna.

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PLASTIC PROTECTORS. 16-page Bulletin P5708 describes plastic plugs and caps; contains a handy cross-reference table.—S. S. White Plastics Div., 10 E. 40th St., New York 16, N. Y.

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ITV, RADIO

CC TV. 16-page pocket-size booklet, "What Closed Circuit Television Means to You," presents CC TV camera systems, applications, and equipment.—Blonder-Tongue Labs., Inc., 9 Alling St., Newark 2, N. J.

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TELEMETERING TRANSMITTERS. Folder titled "New Concept - High Power in Small Packages" describes eight new models.—Telechrome Mfg. Corp., 28 Ranick Dr., Amityville, N. Y.

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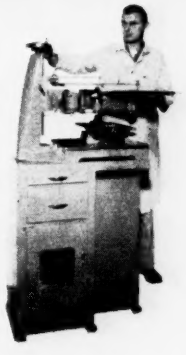

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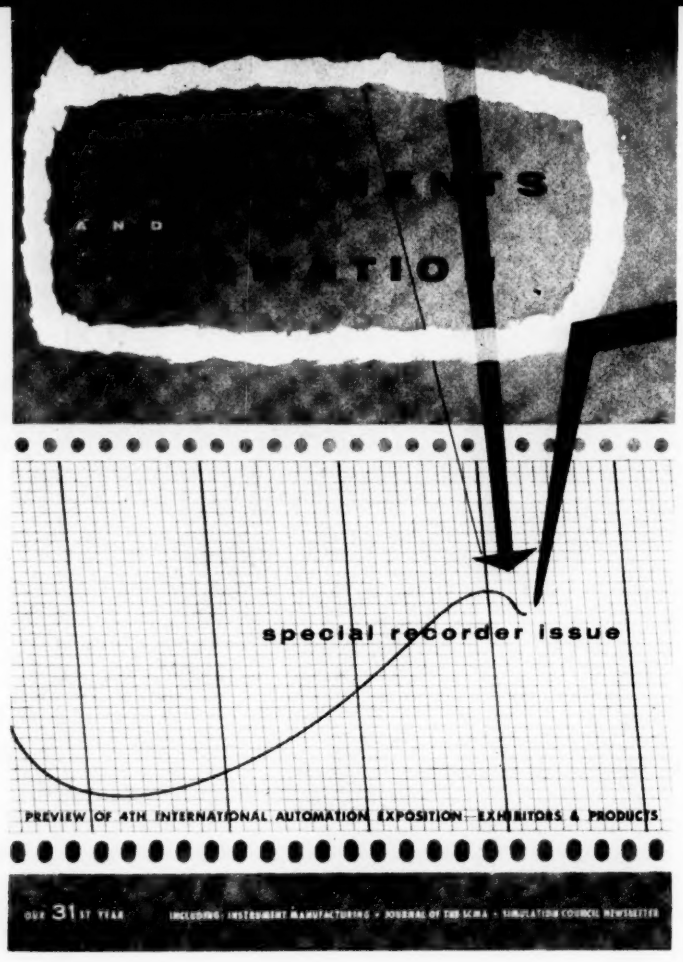

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For details contact any of our offices, listed on page 369. Ad closing date for May 1958 *Instruments and Automation*, April 21, 1958.

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845 Ridge Ave., Pittsburgh 12, Pa.

CC TV. 6-page Pamphlet V-1-58 gives easy-to-read descriptions of Vicon cameras, camera control, monitors, and accessories, with technical information confined to a specs page. —Insul-8-Corp., 1369 Industrial Rd., San Carlos, Calif.

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ELECTRICAL, ELECTRONIC INSTRUMENTS

ELECTRICAL AND ELECTRONIC INSTRUMENTS, accessories and supplies. 256-page Catalog O covers extensive line of equipment, begins with handy index, ends with useful charts, tables, and detailed indexes.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

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DIGITAL VOLTMETER. 4-page Bulletin No. 19-2 describes new Model 401 dc digital voltmeter featuring new single-plane wide-angle readout with automatic polarity indication and automatic decimal placement, and automatic continuous standard cell calibration.—Kin Tel, 5725 Kearny Villa Rd., San Diego 11, Calif.

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TRANSIENT RESPONSE ANALYZER. 2-page bulletin describes new Model RA-1 utilizing a dynamic electric model of mechanical system being investigated, and a varying voltage source representing force on mechanical system.—Dynamic Measurements Corp., 40 S. Los Robles, Pasadena, Calif.

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OVERVOLTAGE PROTECTION. 2-page Bulletin 1050, "Voltage Monitor Case History" is believed to be unique and has never been done before in this manner.—San Gorcinto Div., Assembly Products, Inc., P. O. Box XX, Palm Springs 9, Calif.

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PULSE-HANDLING INSTRUMENTS. 4-page comprehensive catalog lists two types of time delay generators and four basic types of pulse generators with several modifications.—Rutherford Electronics Co., 8944 Lindblade St., Culver City, Calif.

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VOLTAGE AND CURRENT CALIBRATOR. 2-page bulletin describes new Model 6020B for measuring complex waveform amplitudes and dc levels.—Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

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INDUSTRIAL TELEPHONES. 20-page Industrial Bulletin contains information on standard telephones and adaptations, chiefly Series 1500 used in private dial, dictating or intercom systems; also handsets, etc.—Stromberg-Carlson Co., Div. of General Dynamics Corp., 100 Carlson Rd., Rochester 3, N. Y.

Circle **589** on inquiry card.

INSTRUMENTS, MACHINES, tools, components and supplies. 16-page condensed catalog lists hundreds of items from dozens of manufacturers —mostly electrical and electronic.—Lectronic Research Labs., 715 Arch St., Phila. 6, Pa.

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ONE-HAND CLAMP-TYPE AMMETERS. 8-page brochure describes and catalogs Tong Test ammeters which can measure both ac (to 400 cps) and dc. —Columbia Electric Mfg. Co., 4519 Hamilton Ave., Cleveland 14, Ohio.

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THYRATRON GRID CONTROLS. 4-page Bulletin 101-L describes "packaged" unit featuring simplified feedback control; presents typical performance curves and other data.—VecTroL Engineering, Inc., P. O. Box 1089, Stamford, Conn.

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MICROWAVE EQUIPMENT. 32-page catalog describes coaxial attenuators, insertion loss test sets, modulated r-f sources, Bolometer Preamplifier modulator, etc.—Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

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RECTIFIERS, TRANSISTORS

SILICON RECTIFIERS. Two 2-page data sheets on new line or axial lead silicon rectifiers featuring high forward conductance and conservative ratings.—Transitron Electronic Corp., 168 Albion St., Wakefield, Mass.

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SELENIUM RECTIFIERS. Special Bulletin 257 gives high-temperature derating curves of new vacuum-processed high-current-density "PettiSel" selenium power rectifiers.—Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N. Y.

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POWER TRANSISTOR. 2-page Engineering Data Sheet describes new DT80 with 80-volt collector diode rating and high dc gain range. Gain at 1.2 amp range is 100.—Delco Radio Div., General Motors Corp., Kokomo, Ind.

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RELAYS, SWITCHES

SNAP-ACTION SWITCH. Bulletin 5200-1 describes miniature snap-action switch for military and industrial applications, especially suited to ganging in multiple circuit applications such as timing devices.—Haydon Switch Inc., 536 So. Leonard St., Waterbury 20, Conn.

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RELAYS. 32-page Catalog C 8 covers "over 1,000,000 dependable relays in stock to serve every purpose."—Relay Sales, Inc., Box 186, West Chicago, Ill.

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PRECISION SWITCHES. 8-page "Uses Unlimited," Vol. 11, No. 2 includes many new types of switches including a plug-in-limit switch which can be replaced on a machine in a matter of seconds.—Micro Switch, Freeport, Ill.

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TOGGLE AND TRIGGER SWITCHES. 2-page Catalog 100-1 describes ten standard types, all UL approved, for small motors, electrical appliances, and electronic equipment.—Sargent Electric Corp., 630 Merrick Rd., Lynbrook, N. Y.

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MERCURY RELAYS. 2-page bulletin describes new RotoRelay featuring mercury-to-mercury contacts, magnetic rotator with low coil-actuating power requirement, and generous safety margins.—Corona Engineering Service, 94-52 Corona Ave., Elmhurst 73, L. I., N. Y.

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RELAYS. 16-page revised Catalog GS-3 describes and lists twelve types of relays; also industrial relay assemblies, enclosures, etc.—Kurman Electric Co., 191 Newel St., Brooklyn 22, N. Y.

Circle **602** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

ELECTRONIC COMPONENTS. 8-page condensed catalog covers components from an analog computer to small resistors.—Servo Systems Co., 55 Meeker Ave., Newark 12, N. J.

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PRECISION POTS. 2-page bulletin describes Metal Film Potentiometers, Type PT-8 to PT-48 with resolution approaching infinity and with wide operating temperature range; ½" to 3" diameter.—Servomechanisms, Magnetics Div., 1000 W. El Segundo Blvd., Hawthorne, Calif.

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CARBON BRUSH REPLACEMENTS. 2-page data sheet gives not only specs but drawings of thirty different styles.—Ohio Carbon Co., 12508 Berea Rd., Cleveland 11, Ohio.

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HOUSINGS AND FITTINGS. 16-page Bulletin 158 is a selection and specification guide to maker's extensive line of cast-aluminum weather-proof and explosion-proof housings; also explosion-proof sealing fittings.—The Adalet Mfg. Co., 14300 Lorain Ave., Cleveland 11, Ohio.

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RF FILTERS. 8-page catalog shows representative types and performance characteristics of various high-pass, low-pass, band-pass, diplexing and multiplexing filter networks, and preselectors.—Microphase Corp., Box 1166, Greenwich, Conn.

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PRINTED CIRCUITS. File-folder style brochure on printed circuitry describes materials, specs and design tolerances; contains application information; explains patented Narcus Process for plating holes.—Printed Electronics, Corp., 7 North Ave., Natick, Mass.

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ELECTRICAL CONTACTS. Revised 16-page General Catalog C-520 describes properties and uses of maker's line; aids in selection and application throughout original-equipment field.—Gibson Electric Co., Box 611, Delmont, Penna.

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ROTARY SOLENOIDS. Six 2-page engineering data sheets, collectively titled Bulletin 1057-S, cover 156 stock models of five Ledex rotary solenoids available for immediate shipment.—G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio.

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INSULATING MATERIAL. 6-page Bulletin 101 covers all types of Mykroy glass-bonded mica, Thermica synthetic powdered mica, and other types of new HF insulating materials.—Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N. J.

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CAPACITORS. 4-page Engineering Bulletin 141-B-1.1 describes complete line of polystyrene dielectric capacitors in hermetically-sealed tubular, bathtub and upright rectangular case styles.—Applications Engineering Dept., Aerovox Corp., New Bedford, Mass.

Circle **612** on inquiry card.

TEST BLOCK CONNECTOR for printed circuits. 2-page bulletin describes new Series 672 test block connector; available in 6 and 16-contacts for easy insertion of standard 0.080 test probe. —Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., L. I., N. Y.

Circle **613** on inquiry card.

FEED-THROUGH CAPACITORS. 2-page Bulletin 617 describes new "hip-mounting" ceramic Type CFT, voltage rating 600 vdc, 4.7 to 1000 mmf.—Cornell-Dubilier Electric Corp., 333 Hamilton Blvd., S. Plainfield, N. J.

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HERMETIC TERMINALS. 2-page Technical Data Sheet EC-1225 describes a new line of metallized ceramic hermetic terminals offered in voltage ratings ranging from 3 kv to 22 kv and with lug, threaded hollow stud or hollow turret head connectors. Thermo Materials, Inc., 4040 Campbell Ave., Menlo Park, Calif.

Circle **615** on inquiry card.

COMPONENTS for television, radio, power, deflection, audio and electronics, are described in 4-page catalog sheet.—Standard Components, Inc., 519 S. Fifth Ave., Mt. Vernon, N. Y.

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CAPACITORS. A series of 2-page bulletins on various new trimmer capacitors, giving characteristic curves and other data.—JFD Electronics Corp., 1462-62 St., Brooklyn, N. Y.

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CONNECTORS

PRINTED CIRCUIT CONNECTOR. 2-page bulletin describes Series 600-93 with exclusive "bellows action contacts" for use with printed circuit boards from $\frac{1}{16}$" to $\frac{1}{8}$" thick.—DeJur-AMSCO Corp., 45-01 Northern Blvd., Long Island City 1, L. I., N. Y.

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SIMPLIFIED CONNECTIONS. 8-page AR Condensed Catalog of maker's plugs explains latest designations, describes principal types.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

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FACILITIES

FACILITIES. 4-page Bulletin GEA-6762 describes integrated commercial facilities for design, development,

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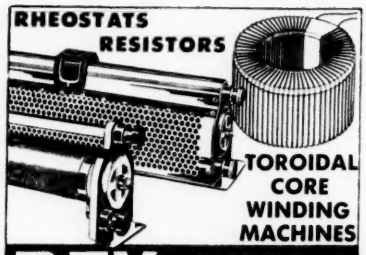

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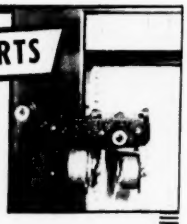

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AN APOLOGY

Instruments Publishing Company wishes to make a public apology to the Precision Thermometer and Instrument Company for inadvertently and prematurely running the Precision Thermometer ad on Stazon pigments in our January issue. Due to a regrettable error, the ad was run one month prior to the date agreed upon between Precision Thermometer & Instrument Company and the P.M.T. Committee. Therefore, we wish to make clear that in no way did Precision Thermometer violate the agreement.

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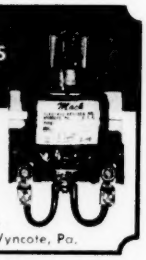

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fabrication and testing of both plate and rod-type nuclear fuel elements.—General Electric, Apparatus Sales Div., Schenectady 5, N. Y.

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FACILITIES. 8-page facilities brochure outlines molding facilities and finishing plant, pictures parts in which company specializes: electrical and electronic components, instrument housings, etc.—Insulation Mfg. Co., 11 New York Ave., Brooklyn 16, N. Y.

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CERAMIC FERRITES. 6-page brochure describes the over-all nature and scope of company and its operations.—Thermo Materials, Inc., 4040 Campbell Ave., Menlo Park, Calif.

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FACILITIES. 12-page brochure describes facilities for engineering, research, design and production of electronic and electromechanical products and assemblies.—Gray Mfg. Co., Industrial Div., 16 Arbor St., Hartford, Conn.

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FACILITIES. 4-page bulletin describes facilities for developing and building special-purpose instruments and complete systems; cites examples in geophysical, medical and other fields.—Electro-Mechanical Development Co., 2337 Bissonnet, Houston 5, Texas.

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FABRICATION

JEWELERS' LATHE ACCESSORIES. 2-page Bulletin S describes four types of heavy-duty slide rests, two lever-feed attachments, two screw-feed attachments, and extra-fine-tooth circular saws.—Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 21, Calif.

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WELDING EQUIPMENT FOR SMALL PARTS. 2-page bulletin describes bench welding head, miniature precision head, stored energy power units, stored energy welder, portable ac timer controlled welder, etc.—Ewald Instruments, Kent, Conn.

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SPRING COILER. 4-page bulletin describes new versatile inexpensive coiler said to be the only one filling needs of maintenance departments, tool rooms, design and experimental shops, etc., as well as production lines.—Perkins Machine & Gear Co., West Springfield, Mass.

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CLEAN ELECTRICAL CONTACTS. 2-page bulletin discusses properties and uses of "Cramolin" liquid electrical contact cleaner, preservative, anti-corrosive as well as lubricant.—Caig Laboratories, 46 Stanwood Rd., New Hyde Park, L. I., N. Y.

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ZAHM SAMPLER COATER. 4-page Vol. 5 No. 45 of "Newsletter" describes new equipment for lab study of painting materials and for small part production.—Gardner Laboratory, Inc., P. O. Box 5728, Bethesda 14, Md.

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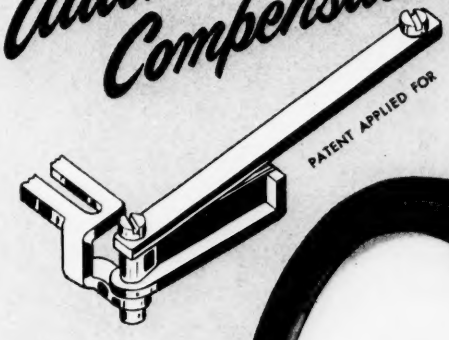

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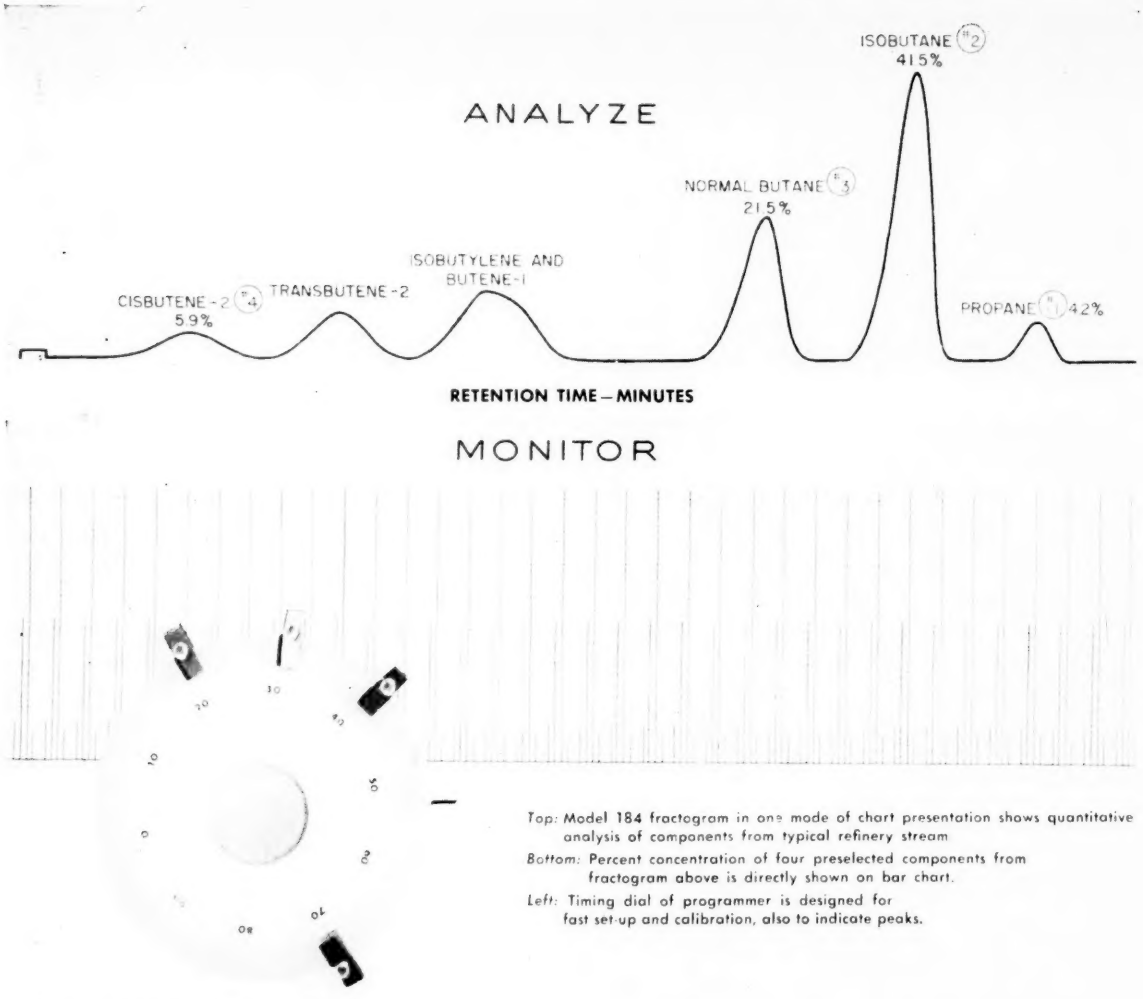

Top: Model 184 fractogram in one mode of chart presentation shows quantitative analysis of components from typical refinery stream

Bottom: Percent concentration of four preselected components from fractogram above is directly shown on bar chart.

Left: Timing dial of programmer is designed for fast set-up and calibration, also to indicate peaks.

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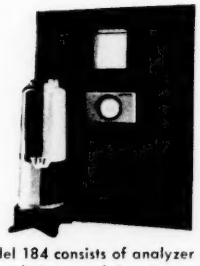
Thanks to its in-plant evaluation by top instrumentation and process control engineers, the new P-E Model 184 can be put on stream with confidence—next year's afterthoughts are already built in.



Model 184 consists of analyzer unit in explosion-proof housing, panel mounted programming and recording units. Instrument monitors up to four components directly on bar chart.

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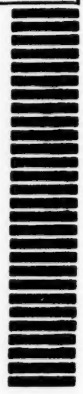

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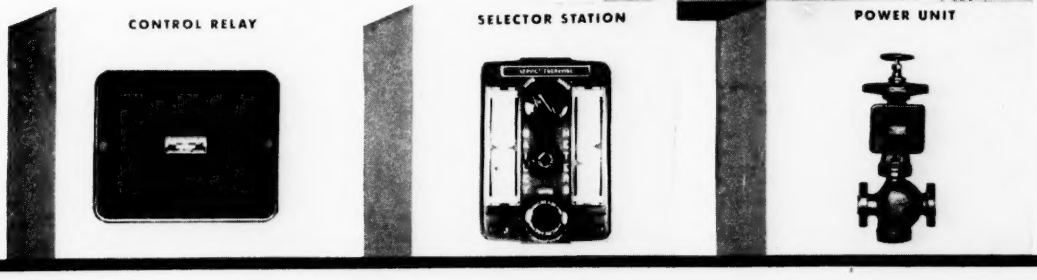

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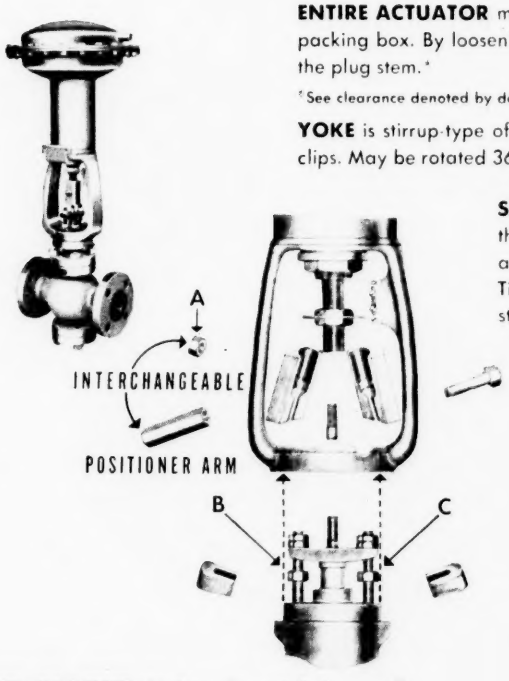

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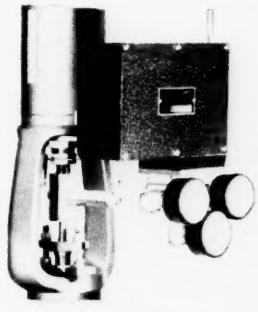

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